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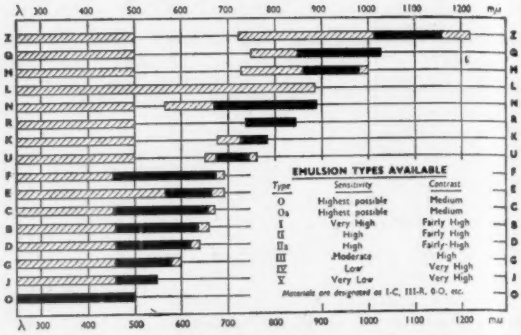
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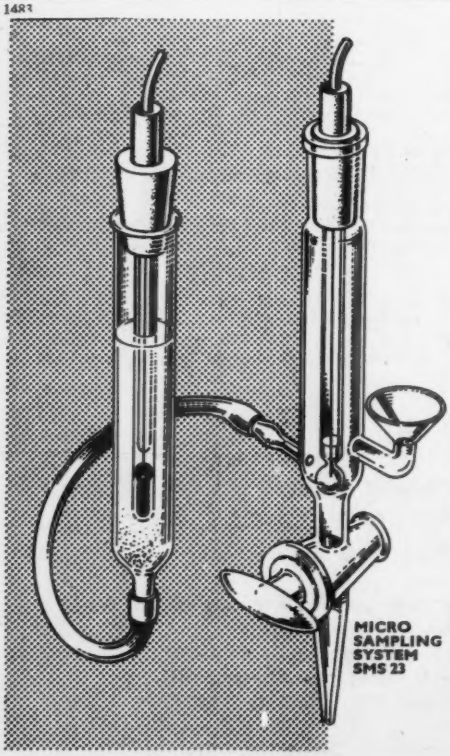

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RESEARCH IN MAN-POWER

ALTHOUGH the recommendations of the National Manpower Council in "A Policy for Skilled Manpower"* are too closely concerned with conditions in the United States to be of more than very indirect interest in Great Britain and elsewhere, the statement prepared by the Council has implications which deserve close attention from all concerned with the use and training of skilled man-power. They bear on the development of technical and technological education; for example, the shortage of science teachers and the differentials between skilled and unskilled workers. Moreover, in spite of the greater difficulty which the Federal State structure of the United States places in the way of a national policy, the report should bring home to any reader the imperative importance of viewing these related problems as a whole and of insisting that the national interest should over-ride sectional interests or prejudices.

Of the five major long-range objectives which the National Manpower Council suggests should be pursued if the United States resources of skilled workers and technicians are to be strengthened, the first—strengthening the contributions made by secondary education to the acquisition of skill—consorts well with the policy of increasing the number of technical school, as well as of grammar school, places announced by Sir David Eccles on April 26, as does Sir David's intention of seeing that no area fails to provide fifteen to twenty-five per cent of such places with the third objective of more equal opportunities for all individuals to acquire skill. It will be noted that in the United States this latter objective is more concerned with the elimination of discriminations of race, creed or sex which prevent the utilization of existing opportunities. In Britain, the problem is rather one of increasing the opportunities available, of seeing that they are fully utilized and that they are related quantitatively to the country's needs for skilled man-power and to the resources from which those needs can be met.

Speaking at the opening of the new Technical College at Devonport and Plymouth, Dr. (now Sir) Alexander Fleck said that Britain has only 64,000 scientists and needs 90,000, and that the shortage is greatest in technologists. He also added that we need people at all levels with the powers of leadership combined with a scientific background. On its production side, industry, for example, needs three types of leaders—scientists, technologists and technicians—as well as a great body of skilled craftsmen. Competent judges, however, have expressed the opinion that the universities, which, since 1931, have increased the number of students reading science and technology by about 14,000, in spite of a decrease of about 1,500,000 in the age-group from which the student element in the population is drawn, are already absorbing very nearly all those who are inclined to take a university degree and have the ability to acquire entrance qualifications to a university. More people can accordingly only be attracted into science and applied science courses by diverting them from other fields of university study.

If, therefore, we are to expand our facilities for scientific, technological and technical training and they are to be used effectively, it is not so much vocational guidance that is needed as more accurate knowledge about our man-power resources and the needs they are called upon to meet. To acquire such knowledge is the first step towards formulating a national policy, and the importance of such reports as that of the Appleton Committee on the Supply of Teachers of Mathematics and Science in Scotland, of Sir Philip Morris's Committee on Graduate Teachers of Mathematics and Science, of the Federation of British Industries on the Shortage of Science Teachers, or of the Central Advisory Council for Education on Early Leaving is to be assessed in this perspective. It can then be seen how much more knowledge is still required and how urgent it is that the Technical Personnel Committee of the Ministry of Labour and National Service and the Scientific Manpower Committee of the Advisory Council on Scientific Policy should expedite their inquiries. Apart from this, the University Appointments Board and such bodies as the Federation of British Industries could possibly help to expedite compilation of the data essential for sound decisions both as to the scale on which new facilities should be provided and as to the balance between them.

Such decisions involve, moreover, consideration of the methods used for training skilled and technical man-power and where that training, in its varied types, is best given, not only as between the university, the college of technology, the technical college or technical school, but as before or after entry to industry. It means that industry must be clear in its mind as to the types and quality of the recruits it requires and the prospects it can offer them. Such questions in themselves affect both the number of science and technical teachers required and the extent of the scientific and technical teaching as well as its nature and the general education to be given. Moreover, as the survey of vocational and non-vocational further education and training carried out for the National Institute of Adult Education by a Committee of which Sir Robert Wood was chairman and Dr. P. F. R. Venables vice-chairman shows, the professional institutions have a major responsibility here.

The Committee reached the firm conclusion that the present narrowness of technical studies is largely due to the framing by some professional and examining bodies of their syllabuses and papers so as to put a premium on the memorizing of facts rather than on the discussion of underlying principles. The Committee suggests that such bodies should re-

* National Manpower Council. **A Policy for Skilled Manpower: a Statement by the Council, with Facts and Issues prepared by the Research Staff.** Pp. xxvi+299. (New York: Columbia University Press, 1954.) 4.50 dollars.

examine the purpose and nature of their examinations, and it also makes the sound suggestion that students should be allowed to use in the examination room the kind of reference books without which they would not dream of practising their profession.

That is one handicap which technical institutions encounter in trying to introduce liberal values into vocational studies. It is clear, however, from this survey that many principals and teachers in such institutions already hold a generous view of vocational education and that, examination requirements apart, the hindrances due to unsatisfactory physical requirements, inadequate library provision and the like, would easily be overcome if industry demonstrated its desire for a more liberal education both by insisting on it in its requirements and by generous support in the provision of new and improved facilities at the technical institutions. The responsibility of industry is fully recognized by the National Manpower Council, particularly in connexion with the fourth of the five long-range objectives which its policy for skilled man-power stipulates—the improvement of the facilities and methods used for training skilled and technical man-power. Indeed, it states frankly that its objectives can be achieved only through a continued and many-sided effort sustained by an informed public opinion and the co-operation of the schools, employers, labour organizations, voluntary groups, the Armed Services and local, State and Federal Governments.

Industry will not, in fact, discharge its major responsibility for the development of the nation's skilled and technical man-power merely by closer attention to training within industry. The very fact that so large a proportion of workers acquire their skill on the job should make industry consider very carefully what technical training it requires of those entering industry. Even where the university graduate is concerned it is at least possible that the arts graduate could be employed in some positions for which it is customary to stipulate the engagement of a science graduate. Such possibilities would be considerably extended if the universities made it their business to see that the arts graduate left the university with at least that understanding of what science is and how it works which should be an essential part of the equipment of every educated man and woman in this technological age.

That bears on the question of general education which in the United States in the technical institute, the vocational high school and the engineering college is now as live an issue as it is in Britain in the colleges of technology, the grammar schools and elsewhere. Although the line between vocational and general education is admittedly blurred to a certain extent, the study made by the research staff of the National Manpower Council brings little fresh information to light that bears on the problem of general education in Britain, other than to indicate the value of general education in developing the versatility and adaptability demanded by an era of rapid technological change with its attendant changes in the types of skill demanded. This is a factor which was emphasized at the recent Conference on Education in a Changing World, as well as at that of the Institution of Production Engineers on automatic methods in industry at Margate during June 16–18. It is clearly one of which close account must be taken both qualitatively in relation to general education and quantitatively in planning the expansion of technical and technological education. Some agreement must be reached as to the nature and extent of the industrial contribution to be given within industry, whether by industrial firms or through the research associations, before any sound assessment can be made of the number, the location and the nature of the courses which the technical colleges and technical schools as well as the colleges of technology should provide.

What needs to be emphasized here is that, so far as the Government is concerned, the division of responsibility between the Minister of Education and the Lord President of the Council offers possibilities of overlapping and waste of effort if either Minister fails to take a broad view of his responsibilities. The Advisory Council for Scientific Policy should be well aware of the danger, and the Parliamentary and Scientific Committee could help to see that there is full co-ordination of effort at a point where it is essential if serious waste of one of our scarcest resources is to be avoided.

The National Manpower Council places a large share of responsibility for the necessary research on man-power resources on the universities and foundations, specifying particularly the desirability of more knowledge as to the complex process of occupational choice, the role of skilled and technical man-power in economic development, the impact of government policy upon the supply of skilled man-power resources and the relation between how people are trained and their subsequent performance at work. In the United States the National Science Foundation is already engaged in some of this fact-finding either directly, or by arrangement with the National Bureau of Economic Research or other bodies, as Dr. A. T. Waterman, its director, indicated at the sixth Annual Conference on Industrial Research on June 6. In Britain, apart from the work of the Technical Personnel Committee of the Ministry of Labour and the Scientific Manpower Committee of the Advisory Council on Scientific Policy and certain inquiries pursued by Political and Economic Planning, some of the investigations under the two Committees on Human Relations in Industry and on Industrial Efficiency in Industry should throw light on the problems indicated by the National Manpower Council; but the technical study which the National Science Foundation is sponsoring of methods for determining the demand and supply of specialized personnel should be of particular interest to Britain.

As to how the training of skilled and technical man-power could be improved the present study gives little indication; but this aspect of the man-power problem should be engaging the close attention of professional institutions and of the trade unions. Without their full co-operation and understanding it will be impossible to frame, let alone execute, a man-power policy adequate to the country's needs, even if the estimates

as to the numbers of skilled workers which the coming of the automatic factory and the adoption of electronic computation will require prove to be exaggerated. When the secondary schools, the technical colleges and the universities have dealt satisfactorily with the problem of general education and secured the increased number of science teachers required to provide both an adequate number of graduates in science and technology but also arts graduates and school-leavers in general with an understanding of what science is which enables them to play an effective part in an industrial world based on science and technology, the increased supply of educated and trained workers will not be used efficiently and flexibly without relaxation of craft rules and trade union practices.

Moreover, besides the character of professional examinations stressed by the National Institute of Adult Education, there are other hindrances to the recruitment of more technical workers. Although their number is increasing, it is not increasing in proportion to the demand for their services which arises from advances in science and technology, particularly when an existing shortage of more highly trained scientists makes it necessary to use less highly trained technicians wherever possible. The automatic factory of the future threatens to displace the semi-skilled operative and thus to accentuate the demand for skilled- and flexible-workers parallel with the tendency for technicians to carry out tasks formerly entrusted to professional workers, and the study made by the National Manpower Council reiterates accordingly the importance of workers possessing a broad foundation of basic knowledge and skills together with attitudes which will facilitate their learning new tasks as the need and opportunity arise.

That, as already indicated, consorts ill with rigid apprenticeship systems or trade union rules and practices. Another difficulty is the decreasing differential between the wages of skilled and semi-skilled workers. Although on the evidence presented to it the National Manpower Council concluded that in the United States at present the long-term decline in the relative wage advantage of skilled workers had not produced and was unlikely to produce a general shortage of skilled workers, it appears to be a factor which should not be disregarded. In Britain, quite apart from repercussions of which the economy has recently been made unpleasantly aware, it could be a serious factor against obtaining a supply of those ready to assume the increased responsibilities as well as acquire the greater skill that the advent of the automatic factory would demand.

Apart, however, from its demonstration of the importance of a carefully thought-out and co-ordinated national policy for scientific and technical man-power and its demonstration of the many factors that enter into the formulation of such a policy, the statement of the National Manpower Council is of interest to British readers for its emphatic indication of the observations in the recent Appleton Report on the crucial importance of an adequate supply of suitably qualified teachers. In the United States, as in Britain, any inadequacy in the teaching of mathematics and science is a national problem which, if unsolved, may endanger the whole national economy, if not indeed the national safety. This is the first and most urgent matter to which our attention should be given, and it is to be hoped that the statement and the evidence on which it is based will receive careful study, above all by those who, like the Parliamentary and Scientific Committee, which has already discussed the expansion of colleges of technology with the Minister of Education, are best placed to further an impartial, all-party approach and to foster the concerted and fully co-ordinated action required.

MEDIEVAL COSMOLOGY

Le Système du Monde

Histoire des Doctrines Cosmologiques de Platon à Copernic. Par Prof. Pierre Duhem. Tome 6. Pp. viii + 740. (Paris : Librairie Scientifique Hermann et Cie., 1954.) 2,900 francs.

THE first five volumes of Duhem's "Le Système du Monde" appeared in 1913. The author then hoped that the work would be completed in eight volumes ; but already, at his death in 1916, ten had been written, and still the task which he had set himself was unfinished. The distractions of war and the economic difficulties that followed, however, prevented any further publication, and for many years copies of the published volumes have been eagerly looked for from second-hand sources. A second edition has now been issued, and with it appears, for the first time, Vol. 6.

This happy event, for which all interested in these subjects will be grateful, has been made possible by the patronage of the Paris Academy of Sciences, to the care of which Mme. Hélène Pierre-Duhem, the author's daughter, long ago committed the manuscript. The co-operation of the Centre National de la Recherche Scientifique was secured and has been promised for the gradual issue of the succeeding volumes. Mme. Pierre-Duhem introduces the sixth volume with a short note explaining these circumstances.

Duhem's "Le Système du Monde", by virtue of its scope, its wealth of detail, and the number of previously unexamined manuscripts on which it is based, is unique among the histories of early cosmological thought. Whereas such a valuable work as Dreyer's "History of the Planetary Systems from Thales to Kepler", for example, is confined strictly to the purely astronomical problem of the structure of the mechanism of the heavens, Duhem treats cosmology in a far wider sense and includes the whole system of philosophy of which astronomy was but one aspect. It is thus at the same time a history of philosophy and a history of science for the periods with which it deals. Though the author's treatment of the subject-matter has not escaped criticism, the work is by common consent an indispensable source of information to all who would form a true idea of the heritage of modern science.

The sixth volume is chiefly concerned with the ebbing of Aristotelianism during the few decades following the death of Thomas Aquinas in 1274. The best-known figures of this period, Duns

Scotus and William of Ockham, as well as those of lesser note such as Henry of Ghent, Richard of Middleton, Giles of Rome and others still less familiar, are presented in the manner characteristic of the author's earlier work, and the story is carried up to Jean Buridan and the beginning of the Paris School of the fourteenth century which, in kinematics in particular, anticipated Galileo in so interesting a manner. For the full treatment of this movement, however, we must wait for the next volume.

The great value of these detailed discussions of the minor, as well as the major, thinkers of those days is that they enable us, as nothing else can, to recover the intellectual atmosphere of the times and to view the problems faced as they then appeared and not as they present themselves in the light of modern knowledge. What now often appears as mere idle verbiage is thus seen to have had a real and vital content, and sometimes to be simply a translation into an outworn language of problems with which we still wrestle. There is a story of an examining body which set the same questions every year, but prevented automatic passing by varying the answers. Whatever may be said for this as an examination device, it is certainly closer to the history of thought than the common practice. The fundamental problems of philosophy remain the same; but each age, seeing them in its own light, gives its own answers. That is not to say that progress is not discernible in the answers.

The appearance of the remainder of this great work will be awaited with feelings of the liveliest expectation. HERBERT DINGLE

BIOLOGICAL GROWTH

Dynamics of Growth Processes

Edited by Edgar J. Boell. (A symposium of the Society for the Study of Development and Growth.) Pp. vii + 304 + 21 plates. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1954.) 60*s*. net.

THIS volume represents the proceedings of the symposium on growth held in Williams College, Williamstown, Mass., in June 1952, under the joint sponsorship of the Society for the Study of Development and Growth and the National Research Council's Committee on Developmental Biology. Although the eleventh symposium of its kind, it is the first to have been published in book form: its predecessors appeared as supplements to the journal *Growth*. Inasmuch as publication did not take place until 1954, and some of the articles deal with lively and quick-moving subjects, one cannot but reflect upon the wisdom of the change.

The symposium is an altogether crisper and more down-to-earth affair than its title might suggest. (What would be the 'statics' of a process which is, of its nature, one of transformation?) A certain order is imposed on what would otherwise be a miscellany by arranging the articles in ascending order of the size of their subject-matter, starting with viruses and protein molecules and ending with the growth of whole organisms and their populations. It is inevitable that the articles on the more rapidly growing subjects should be the first to 'date'. One must not overestimate the danger: new hypotheses on the nature of molecular 'replication' have appeared since the preparation of the present article on viruses; but its general conclusions remain essentially sound. Other articles deal with amino-acid and protein synthesis, the interrelation of nucleus and cytoplasm, and cellular differentiation in animals and plants; with the physical, chemical and endocrine control of growth; with hereditary mechanisms, and with the growth-curves of individuals and populations. All are by scientific workers distinguished for their contributions to these several fields; none is a mere inventory of information, and some are written with a real sense of style.

We are left with a useful synoptic picture of the problems of growth that are most insistent at each level of the hierarchy of sizes and complexity; we learn how little in growth can be usefully thought of as merely scalar and quantitative, and how much, at every level of complexity, depends upon vector properties—organization and form.

CLASSIFICATION OF INSECTS

Classification of Insects

Keys to the Living and Extinct Families of Insects, and to the Living Families of Other Terrestrial Arthropods. By Prof. Charles T. Brues, Prof. A. L. Melander and Prof. Frank M. Carpenter. (Bulletin of the Museum of Comparative Zoology at Harvard College—Vol. 108. New edition.) Pp. v + 917. (Cambridge, Mass.: Museum of Comparative Zoology at Harvard College, 1954.) 9 dollars.

THE previous and first edition of this well-known work appeared in 1932. The present revised edition contains half again as many pages. Most of these additional pages are due to greatly extended lists of references to the different orders of insects, the references to the Diptera, for example, occupying a hundred and twenty-four pages instead of twenty-seven. Another important and useful addition is a section of fifty pages on fossil insects. More than a hundred new illustrations have been added. There are scarcely any typographical errors, and the print is easy to read.

The extended lists of references will be useful to students; but the selection of some of these has not been done with sufficient care. References to the Tipulidae include six pages devoted entirely to listing the papers by Alexander. Some of these should be cited; but the great mass are small papers not relevant to the purpose of the book, as each is concerned with describing a few new species, and no keys are given. Sometimes the same paper is listed as a reference for two quite different groups of insects. For example, Brown's revision of the North American Aegialidae is listed in the references to both the Tenebrionoidea and Scarabaeoidea. No consistent system of abbreviation of references is used.

In a "Conspectus of the Higher Groups of Insecta" (pp. 17–25), the families and higher groups are listed in the order in which they are afterwards treated. In the introduction the authors say that this list ". . . aims to present a natural classification as nearly as this can be expressed in a linear sequence". In this aim they have failed signally. The Collembola, which are not insects, are listed between apterygote and pterygote insects. One of the suborders of the Dictyoptera is given ordinal rank and the other, the

Mantodea, is included in the Orthoptera. It is generally accepted that the Psocoptera are closely related to the Mallophaga and Anoplura; but the Zoraptera, which are unrelated to these three orders, are placed between the Psocoptera and Mallophaga. Stranger still, and quite inexcusable, both the orders Thysanoptera and Hemiptera are entered between the Mallophaga and Anoplura.

The treatment of family relations within orders is very unequal in quality. The beetles fare the worst. For example, no mention is made of the suborder Archostemata, and the Cupididae are placed in the suborder Adephaga. The Chelonariidae and Limnichidae are in the Dascilloidea instead of in the Dryopoidea, where they rightly belong. The families of the Cucujoidea are scattered at random between their superfamilies Mordelloidea, Colydioidea and Tenebrionoidea. Of the families of the Bostrichoidea, the Ptinidae are included in the Dascilloidea; but the very closely related Anobiidae, Bostrichidae and Lyctidae are placed in the Colydioidea. The Ptiliidae are included in the Colydioidea, to which they are not remotely related. Most of these major mistakes occur in the first edition. In the past two decades none, so far as I know, has accepted these views on the classification of beetles.

The Papilionoidea are listed by the authors as the most specialized Lepidoptera and are placed far from the groups to which they are related. The first four families they include in the Tineoidea are all Tineidae, and both their Amadryidae and Setomorphidae are more closely related to *Tinea* than some of the genera included by them in the Tineidae. In the section on Diptera, the Simuliidae are said to be peripneustic, whereas in fact they are apneustic, and they have mistaken the dorsal for the ventral side of the common *Dixa*.

Throughout the work the term 'chitinization' is used when the authors mean 'sclerotization'. On a lighter note, it may be mentioned that, according to the authors, one of the characteristics of Micropterygid larvæ is that they have three-dimensional setæ.

H. E. Hinton

SILICATE THESAURUS

The Physical Chemistry of the Silicates

By Wilhelm Eitel. Pp. xvii+1592. (Chicago: University of Chicago Press: London: Cambridge University Press, 1954.) £11 5*s*. net.

In variety and ubiquity the silicates almost rival the carbon compounds, and there are indeed certain similarities between the two series. The basis of variation in the silicates, for example, is the tetravalent silica tetrahedron (compare with the carbon atom) which may link up with other silica tetrahedra, or with other ions or complex ions, to give stable three-dimensional networks. The numerous ways in which linkage can occur lead to such a variation in silicon/oxygen ratios that in pre-Bragg days a bewildering array of hypothetical 'silicic acids' was postulated; only with the application of X-ray techniques was the simplicity inherent in this apparent complexity revealed.

The compounds concerned being so numerous and varied, it is scarcely surprising that consideration of their physical chemistry has necessitated such a large volume as the one under review. Nevertheless, some idea of the growth of this subject during recent years is afforded by the fact that the volume is almost twice the size of the previous (German) edition of 1941, which in turn, despite the omission of much text-book material, was about half as large again as the original German edition of 1929. The space devoted to the various topics in each edition may also serve as some guide to the relative rates of progress in each field. The present edition is stated to be based upon a translation of a third unpublished German edition completed in 1945; but it is obvious from even a cursory glance that much later material has been added; the most recent reference noted was to a paper published early in 1953.

It is indeed refreshing in these days of symposia to encounter such a comprehensive treatise from the pen of one author, and this only serves to emphasize the vast extent of Dr. W. Eitel's knowledge; his experience of the subject, both as director of silicate research institutes and as teacher, is surely unique. It should be added that he has cast his net widely and has, indeed, made a liberal interpretation of "physical chemistry". The field covered by the book is best indicated by listing the section headings: states of silicates (crystalline; fused and glassy; colloidal); fusion and polymorphic equilibria in dry systems (general remarks; special systems); pneumatogenic and hydratogenic silicates (systems with volatile components; hydrates of the zeolite, permutite group); solid-state reactions (general; ceramics; hydraulic cements); and silicate melts (glasses; slags). In such an immense field each reader could doubtless find aspects he might feel were inadequately treated, or observe omissions; for example, a surprising omission, to the reviewer, was the absence of reference to the book "X-Ray Identification and Crystal Structures of Clay Minerals" (published early in 1951) in spite of the space devoted to this subject. Yet, considering the book as a whole and remembering that it covers the period up to late 1952, little criticism can be made on the grounds either of inadequacy or omission, and the book is indeed a valuable compendium; that it is in many respects encyclopædic rather than critical in no way detracts from its value.

The bibliography is very complete, and the multitudinous footnotes serve as an excellent medium for providing information additional to that given in the text. A special numerical system of referring to journals is employed; although the numbers of the most usual journals soon become familiar, this, at times, forms a source of irritation as one has to consult the key at the end of the book before one can trace the journal—while the possibility of typographical errors in numbering always exists. All six indexes are clear, and appear to be carefully compiled. The diagrams are, on the whole, excellent, although a very few, such as that on p. 1112, might perhaps have been better chosen; the numerous phase diagrams will delight those on whose sphere of work they impinge. A number of typographical errors and misprints were observed; but all should be obvious to the careful reader. Only one slight, and perhaps excusable, error of fact was observed in those sections of which the reviewer has most knowledge.

In general, the book is well printed and well bound, and both author and printer are to be congratulated on its expeditious production. It is a volume which in spite of its cost should find its way on to the reference book-shelf of all interested in silicate chemistry.

R. C. Mackenzie

HISTORY OF COLE (*Brassica* sp.)

By G. E. FUSSELL

A FEW hundred acres of cole or rape are still grown in most counties[1]. Some farmers expanded the acreage under the crop during the war years, notably in Yorkshire, but it has lost the importance it enjoyed between 1650 and 1850. The Fen farmers no longer rely upon it as a cash and forage crop, though it was once a most valuable 'vegetable' for reclaiming newly drained lands.

Like many grasses and roots that have become important in our farming, rape is indigenous, being native to our sea-shores. At the beginning of the eighteenth century the wild *Brassica oleracea* was gathered for human food; people living near the coast preferred it to cabbage. Turner had seen it long before near Dover[2]. It did not become important as a table succulent, but as a green fodder crop and an oil-producing seed crop, its residual cake proving useful as a feeding stuff and manure.

John Smith suggests that some varieties were introduced by the Romans[3]. Rape was certainly cultivated in Classical times. Several Latin works on agriculture contain references to it; but it is not easy to decide just what plant is meant. Pliny is the most definite. He knew three kinds of *rapa*: one flat and broad, the second round like a ball, the third wild with a long radish-like root, pointed rough leaves and acrid juice[4]. This suggests tankard and globe turnips and rape or cole. Pliny thought *rapa* could be sown where scarcely any other crop would succeed, being nourished by mists, hoar frosts and cold to a prodigious bulk. He had seen some of more than forty pounds weight.

Both Columella and Palladius, however, advise that the two things require different soils. The *rapa* delight in low, wet lands, the *napus* in dry sandy soils. Both believed that if grown in the opposite soils the plants would change into each other in two years[5]. The rustic Roman ate both *rapa* and *napus*; but the *rapa* was most useful for cattle. It was used in Gaul as winter feed. Pliny agreed with this. The boiled seed was excellent for fowls, and livestock flourished on the leaves.

All this must have been known to medieval scholars, but did not lead to the cultivation of either kind of *Brassica* as forage or industrial crops. Barnaby Googe, the Lincolnshire squire who translated and expounded the "Whole Art of Husbandry" (1577), was acquainted with Columella's statement and had seen rape or cole cultivated in the Principality of Cleves. He thought it valuable for green manuring, for its oil seeds and sheep fodder[6]. His remarks did not induce anyone, even himself, to grow the crop.

Rape seed was extensively grown in Belgium in the late Middle Ages, to which country it may have been brought from Holland. This was *Brassica rapa rapifera*, described by Dodoens as sown before the winter after corn harvest. It was also sown on the fallow after oats. The crop was heavily manured and was rather costly. A tenant of Hof ter Kluizen who paid 70 pound of rape seed with his corn rent in 1470 could substitute an equal quantity of wheat if rape failed.

A Belgian farmer with more rape than necessary to feed his cattle as green fodder let it run to seed in the spring and harvested the seed for sale. It was grown on a large scale in Waes and sold in the markets of St. Nicholas in Ghent, at Louvain and Mechlin.

The name 'cole seed' first occurred in the sixteenth century when Dodoens mentioned "sloren", a cabbage grown only for its seed. This Lindemans believes to have been developed from rape, though not in Belgium. After 1550 Belgian leases speak of cole-seed instead of rape-seed. This was a more profitable crop, the yield greater and the seed much richer in oil. It was *Brassica oleifera*, and became the most cultivated oil plant of West and Middle Europe.

The centre of cultivation in the Middle Ages was perhaps in the Netherlands, most likely in the north, whence it passed to Belgium, France, Artois and Picardy, and in the second half of the sixteenth century to the Rhineland and mid-Germany[7]. This may be a correct assumption; but the plant or some form of it was known in classical Gaul. Did it continue to be cultivated there, and how did it get to North Holland, whence it could continue its travels in the late Middle Ages?

Whatever the history of the crop in Europe, the drainers who came from the Low Countries with Vermuijden introduced it to the Fenlands of Britain. The fenmen strongly resented the activities of the drainers, and did their best to destroy the works. So early as 1639 there were riots in Lincolnshire, with great loss and damage, especially to crops on reclaimed land, which included "great crops of rape, cole-seed, corn and other grain"; while about 1646 the "Anti-Projector" (an anonymous pamphleteer) was asking scornfully, "What is cole-seed and rape? These are but Dutch commodities and but trash and trumpery"[8].

Many Walloons and French-speaking Hollanders from Picardy and North Flanders settled in Thorney after its drainage by Francis Duke of Bedford in Charles I's reign. They were expert in the cultivation of colza, from which they extracted oil.

The new crop (if it were new) immediately found its way into the text-books. Both Walter Blith and Samuel Hartlib came down heartily in favour of it. They and their successors for a century or more emphasized the importance of obtaining seed from Holland.

Blith looked at the matter both generally and particularly. Cole was most useful on marsh, fen, lands newly recovered from the sea, or any lands flat and rank. It should, as Palladius had said so long before, be sowed about midsummer. The fen-land was carefully prepared. The surface was pared off with a paring plough[10]. The turves were stacked in small heaps and burned (a process called den-shiring elsewhere), the land thoroughly ploughed and ridged up. Cole-seed was then sown, and the crop harvested the following summer[11].

Blith's advice was based on practical work done in the reclaimed Fens. Vermuijden reported in 1652 that 40,000 acres of the South Level had been sown with cole, seed wheat and other grain. In the Bedford Level, "a small quantity of about 28,000a." had been cultivated. The result of the first year's crop was most profitable[12].

Hartlib optimistically estimated that 380,000 acres of the great fen of Lincoln, Cambridge and Huntingdon had been reclaimed by 1655. Its value was high. A friend offered a mark an acre for 900 acres on which to sow rape, land formerly scarcely worth 12*d.* an acre.

The work went on and by the end of the seventeenth century a large area was cultivated. In 1657 it was grown between Ely and Southery; by 1696 there were great crops between Spalding and Crowland. Here were oil mills in which the seed was crushed between marble stones imported from Germany. Shipments of rape oil to London were made both from Wisbech and King's Lynn at about this time[13].

Rape was grown in Kent almost as early as in the Fens. Rochester exported thirty quarters of rape-seed to Dieppe in 1660–1—presumably the product of the county[14]. Casual shipments, too, went out of Hull between 1620 and 1670[15], although where it was grown I cannot say—perhaps in Yorkshire or in Lincolnshire; it may have been grown in Essex before the Fens. Five quarters of rape-seed was exported from Malden in 1611, and ten quarters from Colchester in 1631, Maldon exported 353 quarters and in 1642 Colchester exported 5,000 rape seed cake[16].

By 1716 home-grown seed was nearly as good as that imported from Holland; but perhaps not so plentiful. It was still sown at a gallon or 4 lb. an acre in July on carefully prepared land, ploughed in May and again in June. As the crop became more familiar, its use as green fodder and its residue as dry feed was recognized. In Holland, rape was used for feeding oxen in winter, and that lesson was learned. English farmers used it in January, February and March "when other food is wanting". If fed one winter, it would often produce a good crop next year, and when cut the stubbs would sprout again and afford excellent nourishment for sheep.

If for seed it was reaped with the sickle in the same way as wheat, placed in small yealms or heaps to dry, gathered in large sheets and carefully threshed in the barn because very apt to shed. Lincolnshire growers threshed in the field on a sheet laid on a specially flattened piece of ground. The average yield per acre was five quarters, worth £5. Here the refuse cake was used as fuel, because the county was short of wood. Northamptonshire farmers made a better use of the cake. They fed calves from three or four days old on a mixture of powdered cake and water[17] instead of milk. The calves flourished.

The advantages of the crop were so evident that it spread to other places by the middle of the eighteenth century. In the Chiltern country it was a great success. Gloucestershire farmers were growing it on pared and burned land, though they used a breast plough to cut off the turf. Farmers near Chelmsford, Essex, were cultivating it. At Chertsey, Surrey, and Gaddesdon, Herts, the seed was sown in beds and the young plants transplanted when a few weeks old, as Palladius had recommended.

Much of this expanded acreage was for feed. Near Richmond, Surrey, and other places it was given to the ewes that suckled house lamb—a profitable business near London. If fed to cows or sheep, care must be taken not to cause hoven, or make the milk rank by giving too much at first. The animals fattened quickly on it, and a rape crop opportunely provided feed after the turnips were gone. It promoted milk yield, too.

Some farmers had begun to sow rape on one ploughing after a cereal crop, others to sow in February and feed off in midsummer—practices that developed. When sown after a cereal, ten bushels of Newbury or Hampstead peat ashes were added as fertilizer[18]. This was a novel modification of the methods introduced in the Fens.

It was not until 1756 that a hint was given that the rape- and cole-seed imported from Flanders was "not all the same kind". The plant was, said Thomas Hale, equally native of England and Flanders but did better in the latter country. Flemish seed was always to be had and always best[19]. John Mordant was sceptical about overseas seed. Home supplies were excellent. He repeated the general advice, current for a century[20].

A few years later both Nathaniel Kent and James Adam advised farmers to consider that cole occupied the ground for a whole year, and must therefore produce a profit equal to that gained from barley crop and turnip crop together. If they could make it do that, it was in addition exceedingly useful in cleaning and meliorating land.

Adam thought cabbage had begun to supersede it for feeding cattle by 1789. He quoted the Marquis of Turbilly on the Flemish method of sowing the seed in beds and transplanting it like ordinary garden cabbage. The land must be ploughed twice before winter, and again in May, harrowed two or three times, ploughed again towards the end of July, the seed sown and harrowed and rolled in. 24 lb. seed sown on three acres would provide plants to set out on twelve acres. Early in October the best plants were selected for transplanting into rows one foot apart at six-inch intervals in the rows. Harvesting was carried out as usual. Essex farmers, however, generally reaped cole and prepared frames lined with threshing cloths, each drawn by one horse, to receive the heads of the plants as fast as they were cut off. When properly managed, nothing paid better, but the product must have been sold at a high price to cover all the seed-bed preparations and careful handling[21].

Transplanting was done in two ways in Brabant. A hole was made with a special spade at the required intervals and a plant put in by a child, who pressed the soil firmly around the roots, or the plants were placed by hand at regular intervals in the furrows and covered with the earth turned upon them when the ploughman turned the next furrow. The manual method was described by the Abbé Mann. Arthur Young saw it near Cambrai on the oat stubble after one ploughing in October. Here and at Valenciennes the hole for the plant was made with a large dibble. Josiah Ringstead was the first to recommend mixing the seed with earth or sand to prevent it growing in clusters[22].

Young himself could not make cole-seed yield heavily enough to be profitable, though Philip Miller had said one acre of cole equalled two of turnips for feeding[23]. In spite of this, Young was enthusiastic about its cultivation by Essex farmers in 1807. They often grew cole on a fallow as they did turnips; but had generally found newly broken-up ground best. Three or four pints of seed were enough if grown for seed production, but for fodder five or six were often necessary. Charles Vancouver described transplanting at twelve inches square at a cost of a guinea an acre that was always profitable. The straw of rape made excellent litter. His estimate of yield was twenty-nine bushels an acre; but Mr.

Dudley, of Bradwell, an experienced grower, set it at thirty-four. Dudley thought feeding cole-seed in the county was declining, the leaves having been found better. Nevertheless, it was widely grown from Hedingham and Finchingfield to Maldon for seed. The farmers found it very profitable. In Rochford Hundred immense quantities were grown, cut with a short, strong scythe made for the purpose, and carted to the farmyard to feed bullocks. Mr. Claydon, of Audley End, and many other farmers all over the county sowed it for sheep or green manure. The crop was prohibited on the Winchelsea Estate, Foulness Island, because it exhausted the land and promoted weeds—an opinion then not widely shared[24].

By this time farmers in several counties often far removed from the Fenland grew the crop. Among these were Gloucester, Hampshire, Kent, Stafford; the farmers of Lincoln, Suffolk and Yorkshire continued their allegiance to it[25].

Sinclair was as enthusiastic as Young. In Flanders, he said, it was found to destroy the *gyrllo talpa*, so injurious in wet soils. The cake had long been used in various parts of England as manure, particularly in Yorkshire and Norfolk. It was broken up and ploughed in about six weeks before seeding. Ploughed in with wheat seed, it was particularly forcing. Flemish farmers of seventy-five acres bought as much as 5,000 rape cakes and 3,300 poppy-seed cakes, costing nearly £60 a year[26].

Twenty years later, members of the newly formed Royal Agricultural Society could read in their *Journal* how the plant was grown in Schleswig-Holstein, Lauenberg and Mecklenberg, and praise of the oil produced from the seed. When purified, it was without smell, gave a brilliant clear burning flame and was universally used all over Germany in the saloon and cottage[27].

The hint by Thomas Hale in 1756 that the seed obtained from Holland was not always the same was elaborated by the Rev. W. L. Rham, himself a Dutchman who had settled in England. *Brassica campestris* and *Brassica napus* were often confounded in Britain as rape. In the Netherlands, *B. campestris* was sown in summer and transplanted before winter and produced flowers and seed in the following year. *B. napus* was usually sown in spring, ripening its seed the same season[28].

Loudon, too, was emphatic about the distinction between the two plants for rather more botanical reasons. "Rape", he wrote, "is *Brassica Napus*, a biennial plant of the turnip kind with . . . a woody fusiform root hardly fit to be eaten", that is, the wild rape of Palladius. Von Thaer and Candolle both agree, he said, that the French or Flemish colza was a different plant from our rape, more of the cabbage kind, having a cylindrical root, cut leaves and greater hardiness. According to these authorities, it was *Brassica campestris oleifera* and the seeds produced more oil, in the ratio 955 : 700. For leaves as sheep feed and for oil this had been cultivated from time immemorial. He elaborates its use as winter forage cut green, the oil-producing qualities of its seed and the use of the residual cake for fattening livestock, and manure.

All these uses continued to be advised by the nineteenth-century didactic writers. Sussex farmers occupying 200 or 300 acres were told to sow one-tenth of their acreage to rape (*B. napus*). Sown at the latter end of May, it could be stocked about six weeks later, and would fatten and finish great quantities of sheep and lambs until near Michaelmas. It would then stand the winter on land not too wet. The following year it should be left to stand for seed to make it profitable. The yield was estimated at about forty bushels an acre, and the price as rather better than wheat. The profit was all the greater because the cost of seed and tillage was repaid by the sheep feed. The haulm could be fed to cattle and the stover after threshing used as hay. The cake could be used as manure[29].

During the first decade of the Royal Agricultural Society many essays on this crop appeared in its *Journal*[31]. These and the references in other societies' publications and the general agricultural press indicate a widespread interest in the crop.

Most rape grown in the second half of the nineteenth century was for feed—not for seed. On the chalk and oolite, rape was often grown mixed with vetches and turnips about 1880, but most frequently by itself. *Brassica campestris* described by R. Scott Burn as smooth-leaved summer rape, or colza, was suited to fen soils rich in peaty matter; *Brassica napus*, the rough-leaved winter rape or cole-seed, to clay soils. Some farmers were uneconomical enough to burn the haulm; but this was a mistake. It made excellent litter.

The methods of cultivation and manuring had not changed; but some farmers grew a succession of fields or patches of rape throughout the season, beginning with one in April for late summer and autumn feed. The main crop was put in during June, and more small areas at intervals for a few weeks. This method provided a succession of growths that could be used during winter and spring. Some continued the old practice of feeding off in autumn and letting the crop stand until the following year. It was then folded or fed green once more; but this second growth was watery and innutritious[32].

The winter variety, still a main crop, yielded heavily on the rich fen soils in 1914. The ancient idea that neglected turnips and swedes were liable to lose their large and shapely roots and to revert, the swede to the smooth-leaved summer rape, the turnip to the rough-leaved winter rape, was then repeated[33].

With the need for economies in stock feeding between the Wars, many farmers expanded their rape acreage. The need for home-grown feed was intensified by the Second World War; the acreage under rape trebled, though it was not a major crop. In England and Wales some 52,000 acres was grown in 1935; 150,096 in 1944.

All this was grown for feed. The seed required for oil is imported; 13,419 tons during 1953 to make 4,697 tons of oil. This is not new. The quantities were 206,111 quarters in 1865; 474,667 quarters in 1866; 610,782 quarters in 1867. An experiment in making oil with home-grown seed in 1951 was not economic, insufficient oil being extracted to make seed-growing pay. In spite of this, it looks as if rape will continue to contribute substantially to feeding our livestock.

One of the main uses of the oil produced by the French, Flemish and Dutch refugees, both in their native countries and the reclaimed fens, was lighting. Condemned as it was by the irate fenmen, it provided better light than rushlights or tallow candles. Indeed, it competed with whale oil if the couplet:

"Here grows proud rape, whose price and plenty foyles
The Greenland trade and checks the Spanish oyles"

is to be believed. In the early railway age it supplied railway lamps, and later some used it in bicycle lamps. In some backward countries it is still used as an illuminant. Some Asiatics cook and make margarine with it; but here and in the United States its use is for quenching steel and as a machine lubricant.

The plant, always grown more in France, Belgium, Holland and Germany than here, is to-day almost world-wide, being grown in Hungary and the U.S.S.R., in China and India as well[24]. Here rape is now grown only for feed. Its cultivation undoubtedly owes much to the 'Dutch' settlers and to the continual reference to Low Countries' practice made in our farming text-books throughout the first two centuries of its adoption. The long-sustained trade in imported seed from Flanders and Holland, so rigidly insisted upon by a succession of writers, has helped to keep up the excellence of the crop.

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[10] *Ann. Agric.*, **43**, 126 (1805).
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[15] Letter from Brooks, F. T., University of Hull, December 21, 1954.
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MAN-MADE DIAMONDS

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IN the 1920's it was quite widely believed that diamond had been made from carbon under conditions of high heat and great pressure. The story was indeed one to capture the imagination. It involved famous chemists, a thoroughly fascinating subject and very striking experimental techniques.

In the recent past, however, informed scientists soberly agree that there has been no certain example of diamond production in the laboratory. More than a century of claims and counterclaims for the synthesis of diamond attest to the fascination of the subject and the extreme difficulty of the experimental techniques. Henri Moissan dissolved sugar charcoal in molten iron and quenched the solution in cold water in order to crystallize the carbon under the great internal pressure supposedly generated by contraction as the mass cooled from the outside. When the metal was dissolved from the solidified melt, there remained traces of transparent material having optical properties similar to those of diamond and giving some carbon dioxide upon combustion. Moissan therefore believed he had made diamond.

In 1880, J. B. Hannay reported he had made diamonds by heating a mixture of hydrocarbons, bone oil and lithium at red heat in sealed wrought-iron tubes. The project was said to be fraught with great difficulty because of exploding tubes; only three out of eighty held. Hannay's identification of his diamonds seemed very conclusive, since it even included a density of 3·5 and a carbon analysis of 97·85 per cent.

Sir Charles Parsons tried for thirty years to synthesize diamonds, including in his experiments many attempts to duplicate the work of Moissan and Hannay. At first Parsons thought he had succeeded; but later, having some doubts, he scrupulously re-investigated all his work on the subject. Parsons's new work clearly demonstrated how he had been misled into regarding as diamond various transparent, singly refracting minerals (spinels) which were very resistant to chemical reagents and would not burn. He finally concluded that neither he nor anyone else had ever succeeded in making diamonds in the laboratory.

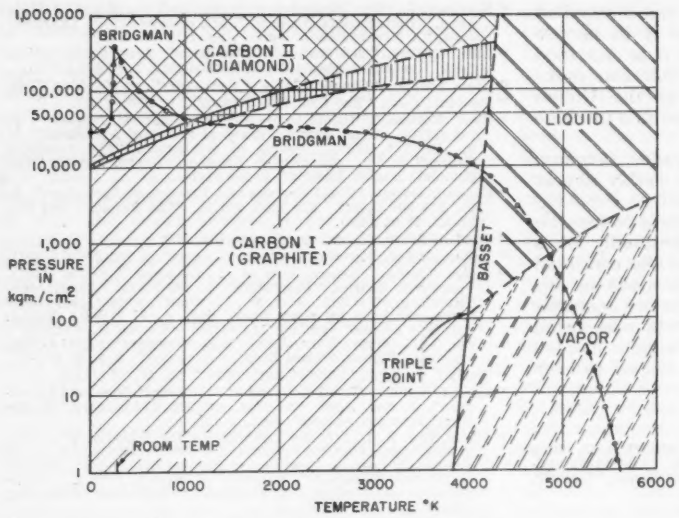

Fig. 1. Phase diagram of carbon

The early claims to diamond synthesis were again reviewed by Prof. N. V. Sidgwick, of Oxford, in 1950, and Henry Eyring, of the University of Utah, in 1952. These authorities conclude that the synthesis of diamond in the laboratory has never been shown to be a success, and that thermodynamic considerations make it seem improbable that diamonds could have been formed under the conditions used in the experiments reported.

For a full account of the arguments the reader is referred to an extensive literature on the subject, a bibliography[1–24] for which is appended.

Suggestions from Thermodynamics

The phase diagram for carbon as now understood is plotted in Fig. 1. Only the boundary between graphite and its vapour at low pressure is accurately established by experimental measurements. The boundaries at higher pressures between graphite, vapour and liquid are based on the work of Basset, and are not fully accepted.

The location of the boundary between the graphite and diamond-stable regions has very little direct experimental evidence at present. The position of the lower temperature part of this boundary was calculated by thermodynamic methods by Rossini and Jessup[25] of the U.S. Bureau of Standards in 1938. The higher temperature part of the boundary shown by broken lines is purely extrapolated from the other part, as the physical data have never been obtained.

The chain-line running across the diagram shows the upper limits of pressure and temperature that are known to have been reached in controlled experiments (this excludes atom bombs) according to the published literature. Prof. P. W. Bridgman, of Harvard University, is the outstanding investigator in this field, working up to more than 400,000 atmospheres at room temperature. He also held temperatures near 3,000° K. at 30,000 kgm./cm.² for very short intervals of time.

The diagram shows that Bridgman has operated well up into the diamond-stable region and has tried many times to synthesize diamonds but without success. He has stated in several of his papers that the reason for his lack of success is that at the relatively low temperatures at which his experiments were carried out the rates of reaction were negligible. He recognized the necessity of going to higher temperatures; but he had not developed apparatus capable of operating at these high pressures and temperatures simultaneously. The maximum conditions he has reported in this direction were 30,000 kgm./cm.² and 2,200°–3,000° K. for periods of one or two seconds.

Bridgman[19] attempted to establish a point on the diamond–graphite equilibrium curve in a series of experiments in which diamonds were heated to about 2,500° K. for a few seconds at pressures which were increased until the diamonds failed to graphitize. This pressure was reached at 30,000 kgm./cm.². He suggested in his paper that this point, 30,000 kgm./cm.² and 2,500° K., might lie near the diamond-graphite equilibrium curve.

In Bridgman's experiment the possibility that pressure reduced the rate of conversion of diamond to graphite cannot be ruled out. If so, the diamonds would fail to graphitize at 30,000 kgm./cm.² in the few seconds at high temperature available. If this be the case, the point 30,000 kgm./cm.² and 2,500° K. is still within the graphite region of stability.

The known evidence about the thermodynamic stability for diamond and graphite led us to believe that diamonds could be formed in the pressure region 30,000–100,000 kgm./cm.² at temperatures somewhere in the range of 1,000°–3,000° K.

Pressure Vessels

Practically all known ultra-high-pressure generators are based on the principle of pushing a piston into a cylinder that encloses the substance to be subjected

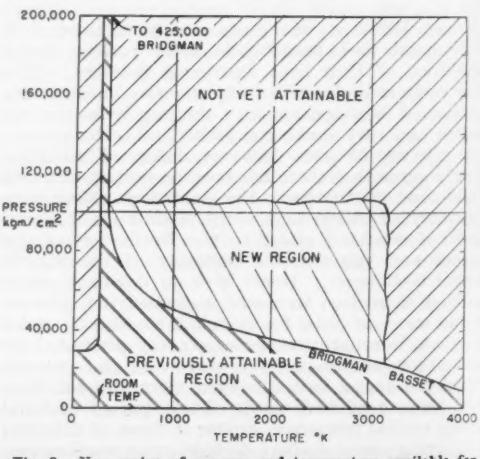

Fig. 2. New region of pressure and temperature available for research

to the pressure. The main factor which limits the maximum pressures that can be reached within vessels is the strength of materials. The strongest steels in the most favourable form and size (piano wire, for example) have ultimate tensile strengths of the order of 14,000–21,000 kgm./cm.^{2}. Sintered carbides, such as 'Carboloy', have compressive strengths of the order of 50,000 kgm./cm.^{2} or more. The pressure required for reasonably rapid synthesis of diamond was thought by our group to be above the compressive strength of 'Carboloy' in the range 50,000–100,000 kgm./cm.^{2}.

Merely making the walls thicker on a pressure vessel contributes very little to its pressure-holding ability after a certain wall thickness is reached. By using multiple support bands on the cylinder part (a technique used years ago in making large gun barrels), and special sealing gasket devices between

(*a*) (*b*)

Fig. 3. Man-made diamonds. (*a*) 1-mm. diamond shown with phonograph needle. (*b*) 0·2–0·5-mm. octahedra

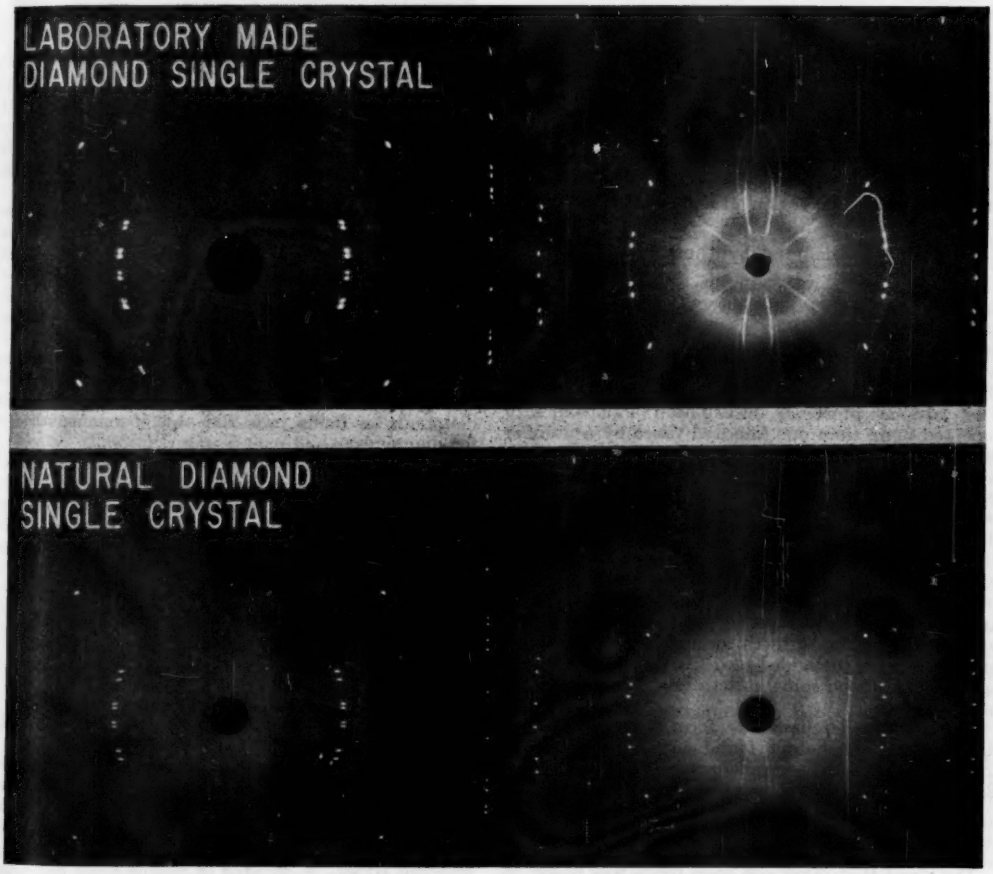

Fig. 4. X-ray diffraction patterns of man-made and natural diamond (powder camera photograph)

the piston and cylinder, Bridgman had developed pressure vessels good for 50,000 kgm./cm.² at room temperature. At high temperatures, materials get weaker and in general the attainable pressures are lower.

By developing some new ways of distributing stress and giving support to critical parts, our research group has succeeded in developing pressure vessels that operate at pressures up to at least 100,000 kgm./cm.² and temperatures in excess of 2,300° K. for hours of continuous operation.

Calibration of Pressures and Temperatures

Pressures of this magnitude are calibrated by making use of four of the electrical resistance transitions observed by P. W. Bridgman[26] in the pressure region up to 80,000 kgm./cm.². The transitions are bismuth 25,400, thallium 45,000, cæsium 55,000 and barium at 80,000 kgm./cm.². For pressures greater than 80,000 kgm./cm.², the melting point of germanium as a function of pressure was used. It was found to decrease linearly with pressure to press loads corresponding to 100,000 kgm./cm.².

Temperatures inside the pressure cells are measured by use of thermocouples, melting points of materials, change of electrical resistance of wires, Curie points of magnetic materials, thermocolour paints, etc.

Region now Available for Research

In Fig. 2 appears a pressure–temperature diagram, with linear scales on both axes, showing the new region of exploratory research which has been opened up by the development of our new high-pressure and high-temperature apparatus. Note that the newly attainable region covers about as much area as does all the region previously attainable.

Diamond Synthesis

The new region of attainable pressure and temperature extended well into the diamond-stable region as defined in Fig. 1. Under these supposed diamond-stable conditions, processes were discovered which yielded diamonds ranging in size from less than 100 microns to more than 1 mm. along an edge. The various processes have been independently repeated more than one hundred times by a number of workers in this Company. Each time crystals were grown which pass the critical tests for identification with diamond. The present chamber sizes permit the synthesis of up to about ¼ carat of diamond material.

It is not necessary to introduce diamond seeds. Nucleation and growth occur spontaneously and profusely when diamond-stable conditions are reached. In some of the early successful work, diamond seeds were added; but growth occurred independently and apart from the added seed. In a few cases under special conditions, some growth has occurred on the seed crystals.

The man-made diamonds form in many of the different crystal habits found in Nature. These include octahedra, tetrahedra and dodecahedra. Some typical forms are shown in Fig. 3.

Proof that Diamonds were Made

The proof that diamonds were made was based on the following conclusive tests:

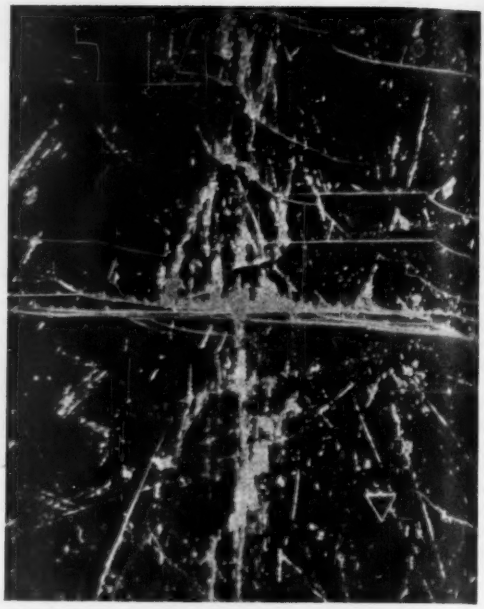

Fig. 5. Scratches made on natural diamond 111 face with man-made diamonds. A large number of scratches appear in a generally vertical direction down through the centre of the picture. The horizontal marks are growth steps on the crystal face. The triangular pit in the lower right-hand corner is also a typical growth mark found on diamond faces

(1) Identity of crystal structure of man-made diamonds to natural diamonds as determined by X-ray diffraction patterns (Fig. 4).

(2) Chemical analysis to show that crystals made were composed of carbon. Those analysed were 86 per cent carbon, 14 per cent inorganic ash identified with the growing media.

(3) Hardness tests. The laboratory-made diamonds were hard enough to scratch the hardest face, the 111 face, of natural diamond (Fig. 5).

(4) Repeatability. The synthesis of diamond has been repeated, entirely independently, by a number of workers in the General Electric Company. The diamonds so made pass the above conclusive tests for diamonds.

In addition, it was shown that the index of refraction for the man-made crystals was within the range 2·40–2·50. Mineral compilations[27] list five isotropic minerals having a refractive index near this range. Natural diamond is one of them and its value is 2·419. The other four are:

	Index of refraction	Moh's hardness
Franklinite, $(Zn,Fe,Mn)O\cdot(Fe,Mn)_2O_3$	2·36±	6
Perovskite, $CaO\cdot TiO_2$	2·38±	5·5
Sphalerite, (Zn,Fe)S	2·428	3·5–4
Eglestonite, $Hg_3Cl_2.Hg_2O$	2·49±	2·3

These four are ruled out as possibilities by the other critical tests.

The result of more than four years effort in this laboratory has been the development of equipment capable of holding pressures and temperatures in the diamond-stable region for hours at a time. Synthesis of diamond has been accomplished more than a hundred times. A number of people have independently repeated the various diamond-making processes

successfully. These laboratory-made diamonds can scratch natural diamonds and have a crystal structure identical with natural diamonds.

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NEWS and VIEWS

The Astronomer Royal: Sir Harold Spencer Jones, K.B.E., F.R.S.

SIR HAROLD SPENCER JONES, Astronomer Royal at the Royal Greenwich Observatory, will retire on December 31. Sir Harold has had a long and distinguished career as an astronomer. Isaac Newton Student and Smith's Prizeman at Cambridge, chief assistant at the Royal Observatory during 1913–23, H.M. Astronomer at the Cape during 1923–33, and Astronomer Royal since 1933, he has left his mark on each of the institutions which he has served. His record of achievement at the Cape can only be compared with that of Sir David Gill; by their efforts and under their leadership the Cape Observatory was made a leading centre of astronomy. The tenth Astronomer Royal will always be associated with the move of the Royal Observatory from Greenwich to Herstmonceux. Conditions at Greenwich have been such that the observing instruments could with advantage have been moved half a century ago; but it required boldness to consider a move of the whole establishment to the scientific isolation of Herstmonceux. The numerous difficulties associated with this move, aggravated by post-war conditions, are known in detail only to the Astronomer Royal himself; but it is clear that they, and his far too numerous official duties outside the Observatory, have imposed an almost intolerable burden. He must be looking forward to the freedom to resume his own scientific work on the fundamental astronomical constants, just as astronomers everywhere will be looking forward to the results of this work.

Prof. R. v. d. R. Woolley, O.B.E., F.R.S.

BRITISH astronomy is fortunate in the choice of Prof. R. v. d. R. Woolley as the eleventh Astronomer Royal. His researches on fluorescence and non-coherence in the formation of absorption lines, his investigation of convection in the solar photosphere and, with Allen, of the physical conditions in the solar chromosphere, have made him one of the leading authorities in astrophysics. As chief assistant at Greenwich during 1933–37 he became well acquainted with the older branches of astronomy and had the imagination to see how the equipment there could be used with advantage in the re-measurement of physical double stars. His skill in research is matched by his success as an organizer and administrator. Under his direction the Commonwealth Observatory at Canberra has become one of the leading observatories in the world. While carrying his own research into new fields, he has at the same time attracted and inspired a strong group of workers, and has provided modern equipment including a 74-in. reflecting telescope now in course of erection. He has been successful in securing co-operation with American astronomers, so that not only is there an active exchange between Canberra and the Pacific Coast observatories, but also the Yale–Columbia Station has been moved to Mount Stromlo.

Prof. Woolley goes to the Royal Greenwich Observatory at a critical period. The past fifty years have witnessed a dramatic revolution in astronomical knowledge and in the techniques of observation, much of it initiated on the American continent. In the same period, Greenwich has continued conscientiously to amass observations, though often with obsolescent equipment and methods and on programmes some of which stem from Airy. It is right and proper that the older methods and problems should not be lightly abandoned; but the time is more than ripe for a fundamental re-assessment of the functions of the Royal Observatory, its equipment and method of staffing.

College of Aeronautics: Principal A. J. Murphy

PROF. A. J. MURPHY has been appointed principal of the College of Aeronautics, Cranfield, as from October 1. Prof. Murphy graduated at the University of Manchester with first-class honours in chemistry and later was awarded an M.Sc. of the same University. After a period as research assistant to Prof. C. A. Edwards in the Metallurgy Department at University College, Swansea, and later on the staff of the Metallurgy Department at the National Physical Laboratory, in 1931 he joined the firm of J. Stone and Co., Ltd., as chief metallurgist, and in 1946 became a director of that Company and also of Light-Metal Forgings, Ltd., and chairman of Stone-Fry Mag-

nesium, Ltd. For the past five years Prof. Murphy has been professor of industrial metallurgy in the University of Birmingham, and, since 1953, director of the Departments of Physical Metallurgy and Industrial Metallurgy. He is a past-president of the Institute of Metals, and for the past six years has been chairman of the Inter-Services Metallurgical Council, and is also a member of a number of research associations and committees, including committees of the Aeronautical Research Council.

Gold Medal of the Institute of Navigation: Captain P. van H. Weems

The Gold Medal for 1955 of the Institute of Navigation has been awarded to Captain P. van H. Weems, of the United States Navy (retired), for "his outstanding contributions to the general advancement of air and surface navigation over a period of more than thirty years". Captain Weems's "Star Altitude Curves" are still, after nearly thirty years, the leading form of graphical presentation of star data, and used in conjunction with a second-setting navigational watch, preferably adjusted to keep sidereal time, they provide the quickest way to a navigational fix. By his efforts the Greenwich hour angle, which he advocated as long ago as 1928, was eventually adopted for both air and surface navigation and is now a standard feature of most nautical almanacs. His text-book on "Air Navigation", which was first published in 1931, was awarded the Gold Medal of the Aero Club of France, and he has also written a standard text-book on marine navigation. These three examples represent only a small part of Captain Weems's contributions to a subject which has been, and still is, his life's work; but they serve to show his worthiness to receive the premier British award in the field of navigation.

Royal Society of Edinburgh: Honorary Fellows

The following have been elected Honorary Fellows of the Royal Society of Edinburgh: Prof. Giorgio Abetti, formerly director of the Astrophysical Observatory, Arcetri, Florence; the Abbé Henri Breuil, prehistorian and archæologist, formerly of the Collège de France, Paris; Prof. L. E. J. Brouwer, Department of Mathematics, University of Amsterdam; Dr. Anton Bruun, University Zoological Museum, Copenhagen; Prof. M. Florkin, Biochemical Laboratories, University of Liège; Prof. N. E. Svedelius, Department of Botany, University of Uppsala; Prof. H. Yukawa, Department of Physics, University of Kyoto.

Committee on Colonial Road Research

After consultation with the Department of Scientific and Industrial Research, the Secretary of State for the Colonies has appointed a committee to advise on matters of road research for the benefit of the Colonies. Dr. W. H. Glanville, director of road research, will be chairman, and the United Kingdom membership is as follows: Sir George Burt (Messrs. J. Mowlem and Co., Ltd.); Mr. R. L. Fitt (Sir Alexander Gibb and Partners); Mr. G. H. Hargreaves, deputy chief engineer (civil), Ministry of Transport and Civil Aviation; Mr. R. U. Law (Messrs. George Wimpey and Co., Ltd.); Mr. S. Mehew (Derbyshire County Council); Mr. F. W. Parker (Frederick Parker, Ltd.); Mr. J. L. Phipps (Bitumen Department, Shell Co.); Mr. J. Rawlinson (London County Council); Mr. R. W. Taylor (Crown Agents for Oversea Governments and Administrations); Prof. Gilbert Walker, Faculty of Commerce and Social Science, University of Birmingham; Sir Hubert Walker (Colonial Office); Mr. F. H. P. Williams, Colonial Road Research Liaison Officer, Road Research Laboratory (*ex officio* member). Representatives of Colonial Governments will also serve as members of the Committee.

Colonial Governments have indicated support for the establishment of a Colonial Road Research Section at the Road Research Laboratory to deal full-time with road problems peculiar to tropical and rapidly developing Colonial territories. A Colonial Development and Welfare Research grant has accordingly been made providing funds to meet the cost of the establishment and maintenance of the Section during the financial years 1955–57. Staff for the Section is being recruited, and it is hoped to commence work shortly.

Virology

With the appearance of a new journal, *Virology* (pp. 140. New York: Academic Press, Inc.; 9 dollars per vol.), this useful, but ugly, word of doubtful parentage presumably takes its place as the official designation of the study of viruses. The journal has an impressive editorial board consisting of an editor-in-chief, two editors, and twenty associate editors. Among them are most of the leading virologists of the day; but it is, perhaps, a pity, if it is to be an international journal, that no European plant virologists are included. This new journal is to be welcomed for two reasons: first, since it deals with all viruses, it tends to counteract an unfortunate tendency to keep the different types of viruses in water-tight compartments and to regard plant viruses as something entirely unrelated to animal viruses; secondly, it will help to bring together the many contributions which, at present, owing partly to the extensive background of virus research, are widely scattered in journals often quite unconnected with the study of viruses. It is another step towards the building up of a separate status for the science of virology. The contents of the first number indicate the scope of the journal; there are three papers on plant viruses, three on virus diseases of the higher animals, and three dealing with bacteriophages and cognate subjects. The printing and appearance are of the high standard which we associate with the publications of the Academic Press. There is little doubt that *Virology* fills a definite gap in the literature of the subject, and we wish it every success.

Country-side

To mark the golden jubilee of *Country-side*, the journal of the British Naturalists' Association, it is fitting that special tributes should be paid to the founder, E. Kay Robinson, and to Richard Morse. The journal first appeared in May 1905 as a penny weekly, and, despite vicissitudes, has regularly appeared since that time despite all the difficulties caused by war and lack of finance. Richard Morse took over the editorship in 1928 and has only recently given it up; he has been the main cause of its growth into the substantial journal it now is. Besides tributes, the jubilee number contains articles by H. N. Southern on British mammals; C. B. Williams on phenology; M. B. B. Heath on the night skies of summer; and Bernard C. Pickard on British grasshoppers and crickets. There are also a number of shorter sections describing recent observations by naturalists.

Collected Papers of the Rowett Research Institute

As already noted (*Nature*, **173**, 1124; 1954), summaries of the collected papers of the Rowett Institute became available last year for general distribution, beginning with the volume for 1953. The volume for 1954 has now been published as "Rowett Research Institute: Collected Papers, Summary and Subject Reviews", Vol. 11 (pp. 44, obtainable from the Reid Library, Rowett Research Institute, Bucksburn, Aberdeenshire; 5*s*.). The larger number of papers, seventy-six in 1954 against sixty-seven in the year before, reflects the growth of the Institute. The scope and diversity of its problems may be gauged from the following sub-titles of the summary, again written by the director, Dr. D. P. Cuthbertson: methods; microbiology of digestion; absorption; movements of ruminant stomach; animal behaviour; imbalance of nutrients; bracken poisoning; experimental liver necrosis; metabolism of fat; pig research; lactation; economies in feeding non-ruminants; man; reviews and general articles. There are two welcome innovations in the current volume: the titles in the list of papers are given cross-references to the relevant pages of the summary; and the volume carries two subject reviews covering several years of work on two important aspects of the Institute's research. One of the reviews, by Dr. A. T. Phillipson, is on absorption from the alimentary tract of sheep, and the other, which is by the staffs of the Applied and Farm Nutrition Departments, deals with the practical problem of winter keep. The publication will be welcomed not only by agriculturalists but also by many interested in the fundamental aspects of animal nutrition.

Use of Fibrenyle

Mr. B. H. Newman, of the British Museum (Natural History), has recently described the use of fibrenyle in the preparation of palæontological specimens (*Mus. J.*, June 1955). In the alvar of 1930, a vinyl resin was used for repairing fossils. Later, asbestos fibres were mixed with the alvar and an exceedingly strong and resilient adhesive was obtained. Fibrenyle, a nylon–fibrous thermoplastic which is manufactured as a sheeting or in the form of a dough, has advantages over both the materials mentioned. The dough is dark brown, easily workable, and is soluble in acetone or industrial methylated spirit. The advantages of using this new material are that it can be obtained ready for use, the joint can be finished and made good with fibrenyle at the time of repair, its colour is in harmony with many fossils and it is light in weight.

Social Medicine at Oxford

Referring to the review of "The Meaning of Social Medicine" (*Nature*, June 11, p. 1011), in which the reviewer wrote: "but when he [Prof. J. Ryle] died social medicine languished in the University [Oxford]", Dr. Roy M. Acheson writes: "Although it is true that the University's interest in it languished, the subject itself has continued to thrive. Since the Institute was finally closed in 1953 a small and extremely active department has continued without interruption. This department has consisted of a reader and a statistician as its sole University staff. They have been assisted by a physician on the permanent strength of the Medical Research Council, and a few other medically qualified research workers who have been employed on a temporary or part-time basis when funds from outside sources have permitted. With these meagre resources, an analysis of war-time civilian medical boards and of the Child Health Survey, two major studies which were begun before 1953, have been completed and the results published as a series of communications in the medical journals. New work has been undertaken on problems connected with old age, infant morbidity and mortality, tuberculosis in industry and acute leukæmia in childhood, and some of these new studies also have reached fruition. Finally, in the course of the past two months, papers have been read on two different aspects of the research of the department to the Royal Society of Medicine and to the Association of Physicians of Great Britain and Ireland".

University of London

The following appointments in the University of London have been announced: Prof. D. P. Craig, professor of physical chemistry in the University of Sydney, to the University chair of chemistry with special reference to theoretical chemistry tenable at University College; Dr. B. G. Peters, senior principal scientific officer at Rothamsted Experimental Station, to the University chair of parasitology tenable at the Imperial College of Science and Technology; Dr. E. A. R. Braude, reader in organic chemistry in the Imperial College of Science and Technology, to the University chair of organic chemistry tenable at that College; Mr. G. Keith Allen, to the University readership in mining tenable at the Imperial College of Science and Technology; Dr. J. H. Burgoyne, senior lecturer in the Imperial College of Science and Technology, to the University readership in chemical engineering tenable at that College; Dr. G. L. Kingston, lecturer in physical chemistry in the University of Aberdeen, to the University readership in physical chemistry tenable at the Imperial College of Science and Technology; Dr. J. S. Webb, lecturer in mining geology at the Imperial College of Science and Technology, to the University readership in applied geochemistry tenable at that College.

The Queen's University of Belfast

The Queen's University of Belfast has received the following grants: from the Rockefeller Foundation, 21,000 dollars over two years for the purchase of research equipment for use in the Department of Microbiology; from Imperial Chemical Industries, Ltd., £300 for three years to support work on heterogeneous catalysis; from Messrs. Gallaher, Ltd., £300 per annum under covenant to support work in the Department of Chemistry; from the Aliphatic Research Co., Ltd., £285 per annum for a research studentship in organic chemistry, together with expenses of special chemicals and equipment; from the Royal Society, £580 to support research in mathematics.

Robert E. H. Reid has been appointed to a lectureship in geology.

The Australian National University, Canberra

Dr. I. F. Wright, of the Department of Natural Philosophy, University of Glasgow, has been appointed a research fellow in the Australian National University, Canberra, and will work in the Department of Nuclear Physics with Prof. E. W. Titterton. A visitor to the Department during

August 1955–August 1956 will be Prof. J. B. Warren, of the University of British Columbia, Vancouver.

In addition to 600-keV. and 1,250-keV. Cockcroft–Walton accelerators which have been in operation for some time, the 33 MeV.-electron synchrotron, originally installed at the Atomic Energy Research Establishment, Harwell, and which was moved to Canberra last year, has recently been brought into operation.

Royal Commission for the Exhibition of 1851: Awards for 1955

The Royal Commission for the Exhibition of 1851 has awarded senior studentships for 1955 (value £600–650 a year for two years) to the following for research at the universities indicated: A. D. Buckingham (Sydney), theoretical chemistry at Cambridge; H. E. Hall (Cambridge), physics at Cambridge; J. G. Hughes (Wales), botany at Cambridge; B. G. Forbes (Adelaide), geology at Durham. The Commission has also awarded the following overseas scholarships for 1955 (value £450–500 a year for two years). Canada: G. R. Freeman (Saskatchewan), physical chemistry at Oxford. Australia: J. W. G. Wignall (Melbourne), physics at Cambridge; Miss P. J. Hextall and R. F. C. Brown (Sydney), organic chemistry at Cambridge. New Zealand: R. G. Kulka (New Zealand), biochemistry at Oxford; J. B. Waterhouse (New Zealand), geology at Cambridge. South Africa: Miss E. M. Stephen (Witwatersrand), organic chemistry at the Imperial College of Science and Technology, London. Republic of Ireland: W. Hayes (Ireland), physics at Oxford. Republic of India: D. Premasawarup (Andhra), physics at Oxford. Pakistan: M. M. Khuda (Dacca), organic chemistry at the Imperial College of Science and Technology, London.

Fourteenth International Congress of Pure and Applied Chemistry, Zurich

The Fourteenth International Congress of Pure and Applied Chemistry will be held during July 21–27 in the Swiss Federal Institute of Technology, Zurich, under the presidency of Prof. P. Karrer, of the University of Zurich. In addition, the International Union of Pure and Applied Chemistry will hold its eighteenth conference during July 20–28. The Congress will deal with organic chemistry only, and the scientific programme consists essentially of five Congress lectures, nine section lectures divided between the three sections, and six hundred papers divided between the ten groups. The five Congress lectures will be as follows: Prof. V. du Vigneaud (Cornell University, New York), "Isolation, Structure and Synthesis of Oxytocin, the Principal Oxytocic Hormone of the Posterior Pituitary Gland"; Prof. C. Dufraisse (Collège de France, Paris), "La Photooxydation"; Prof. N. A. Nesmeyanow (Moscow Academy of Sciences), "Zweifache Reaktionsfähigkeit und Tautomerie"; Prof. C. K. Ingold (University College of London), "Developments in the Theory of Steric Hindrance"; Prof. K. Alder (University of Cologne), "Neuere Entwicklung der Dien-Synthese". The three sections will deal with, respectively: theoretical and physical organic chemistry; natural products; and synthetic, industrial and analytical organic chemistry. The ten groups are lettered *A–K* and cover the following topics: *A*, *B*, *C*, molecular structure, stereochemistry and reaction mechanisms; *D*, amino-acids, peptides, proteins, alkaloids and carbohydrates; *E*, *F*, *G*, aliphatic, alicyclic, aromatic and heterocyclic compounds (terpenes and steroids included); *H*, *J*, dyestuffs, high polymers and other synthetic organic compounds; and *K*, biological and medical chemistry, and analytical chemistry. Abstracts of the papers are being published in a special handbook, which will be available at the Congress. The Congress and section lectures will be published in a special autumn supplement (No. 2) of *Experientia* (subscription price, 26 francs; subsequent price, 32 francs), obtainable from Verlag Birkhäuser, Basle. Alternatively, the supplement can be ordered through the Secretary-General of the Fourteenth International Congress of Pure and Applied Chemistry, Zurich 1, from whom further information on all other matters relating to the Congress can be obtained.

Announcements

Prof. Arthur Holmes, regius professor of geology in the University of Edinburgh, has been elected a foreign associate of the Paris Academy of Sciences.

Sir Arnold Plant, Sir Ernest Cassel professor of commerce at the London School of Economics, has been appointed chairman of the Colonial Social Science Research Council in succession to Sir David Hughes Parry. Sir Arnold Plant is already a member of the Colonial Research Council, and has been chairman of the Colonial Economic Research Committee since 1945.

The Seventh British Mathematical Colloquium will be held in Exeter during September 6–8. Those wishing to attend, who have not already registered as members, should write as soon as possible to the Organizing Secretary of the Colloquium at the University College of the South-West, Exeter, from whom further information can be obtained.

The 1955 Biennial Exhibition of the School Nature Study Union will be held at Morley College, Westminster Bridge Road, S.E.1, on July 9, from 10 a.m. until 6 p.m. A variety of exhibits will cover the work of schools, training colleges, dealers, publishers, individuals and organizations interested in various aspects of biology. Further information can be obtained from the hon. exhibition secretary, Raymond Rivers, 12 Hillcote Avenue, Norbury, London, S.W.16.

The Oliver Memorial Fund is offering an award of £50 to a British subject for original work or services in connexion with the research, organization or donor aspects of blood transfusion. Applications or information directing attention to suitable candidates must be submitted before August 31 to the honorary treasurer of the Fund, F. W. Mills, c/o National Provincial Bank, Ltd., Holborn Circus, London, E.C.1.

During June 1954 a conference of those interested in the conservation and protection of Nature in the Near East was arranged in Beirut and was attended by about fifty people from a number of countries in the Near East (see *Nature*, **174**, 289; 1954). The Proceedings, which have now been published by Unesco, include not only copies of the papers which were read but also full accounts of the subsequent discussions, as well as reports from the different study groups. It is printed in French and English.

Erratum. In *Nature* of July 2, p. 16, in announcing the award of the Manley–Bendall Prize, Dr. J. N. Carruthers is referred to as director of the National Institute of Oceanography; this is incorrect, Dr. Carruthers being assistant director of the Institute.

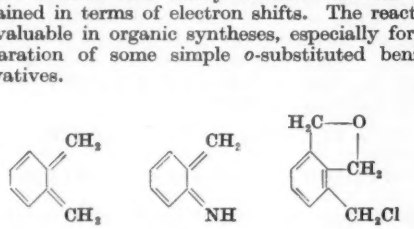
ORGANO-METALLIC COMPOUNDS

THE symposium entitled "Organo-Metallic Compounds", which was held in the University of Manchester on April 21, was one of the annual symposia organized jointly by the Chemical Society, the Institute of Petroleum, the Royal Institute of Chemistry and the Society of Chemical Industry. These symposia have become very popular of recent years, and the interest in this year's subject was evident from the attendance of about four hundred members and the liveliness of the discussion. Dr. R. E. Fairbairn and Dr. H. Gudgeon, of the Manchester and District Section of the Royal Institute of Chemistry, are to be congratulated on their arrangement of so successful a meeting. The highlight was the evening lecture by Prof. K. Ziegler, of the Max-Planck-Institut für Kohlenforschung, Mülheim, who described some of the recent advances in the chemistry of organo-aluminium compounds and their important industrial applications, which were discovered in his laboratory.

It was auspicious that this symposium should take place in Manchester, where the first professor of chemistry, E. Frankland, prepared the first organo-metallic compound, diethylzinc, just over a hundred years ago. The meeting was opened by Prof. E. R. H. Jones, who was chairman of the morning session; Mr. G. Osgood took the chair in the afternoon, and Sir Robert Robinson in the evening. The subject of the symposium was introduced by Prof. G. E. Coates (University of Durham) with a review of some recent developments in the chemistry of organo-metallic compounds. Although there has been little progress in the elucidation of the structures of the chromium phenyls and lithium alkyls, the realization that the lighter elements tend to use all their low-energy orbitals in forming covalent compounds has helped considerably in the understanding of the chemistry of the organo-metallic compounds of the lighter metals of groups 2 and 3 in the Periodic Table. The utilization of all low-energy orbitals is accomplished by the polymerization of the simple molecules, for example, $(R_2Be)_n$ and $(R_3Al)_2$, or, if suitable donor substances are present, by the formation of co-ordination compounds, for example, $R_3\overset{-}{A}l\text{—}\overset{+}{N}R_3$ or $K[BPh_4]$. Sometimes both methods are used together as in a series of compounds $(PMe_3)_2(Me_2Be)_m$ formed by the reaction of PMe_3 with $(Me_2Be)_n$. In an enclosed system the value of m increases in a stepwise manner as the temperature is raised. The stabilities of the co-ordination compounds of the alkyls of the group 3 elements indicate that their acceptor properties increase from boron to aluminium, and then decrease regularly to thallium. Only thallium shows any evidence of d_π—d_π bonding such as is found in the complex compounds of the platinum metals. The donor properties of the trimethyls of the group 5 elements in co-ordination to trimethylgallium decrease monotonously from trimethylamine to trimethylbismuthine.

The other extreme in structural type, when d_π-bonding by the metal is all-important, was next considered by Dr. J. Chatt (Akers Research Laboratories, Imperial Chemical Industries, Ltd.), who discussed the structure of the olefin complexes with metallic salts. He described the structure of the $[C_2H_4PtCl_3]^-$ ion in terms of atomic and molecular orbitals. No simple donation of π-electrons from the olefin to the metal can explain the properties of the stable olefin complexes. A structure was proposed in which the olefin-to-metal bond is a type of double bond. The σ-component of the co-ordinate bond is formed by donation of the π-electrons of the olefin to the metal atom, and the π-type component of the co-ordinate bond by the back donations of an electron pair from a d-orbital (or dp-hybrid orbital) of the metal atom into the anti-bonding π-molecular orbital of the olefin. It is significant that the only metals known to form stable olefin complexes have all their d-orbitals filled and are in low valency states, namely, Cu(I), Pd(II), Ag(I), Pt(II), Hg(II) and, recently added, Rh(I). Some of the more important properties of olefin complexes were described and shown to be consistent with the proposed structure.

Dr. F. G. Mann (University of Cambridge) concluded the morning session with a paper on new reactions of Grignard reagents and their mechanisms. It is known that many β-substituted alkylhalides, for example, $R\text{OCH}_2\text{CH}_2X$, react with magnesium to give ethylene, $Mg(OR)_2$ and MgX_2, instead of a Grignard reagent. Dr. Mann has studied similar systems in which an aromatic nucleus is interposed between the CH_2 groups. When the alkoxymethyl and chloromethyl groups are in *o*- and *p*-positions to each other as in *o*- and *p*-methoxymethylbenzyl chlorides, the alkoxyl and chloro groups are eliminated with the formation, in these examples, of *o*-xylylene (I) and *p*-xylylene respectively. These unstable products immediately polymerize. On the other hand, the *m*-isomer gives a normal Grignard reagent. *o*-Methoxymethylaniline with phenylmagnesium bromide gives a small proportion of polymerized *o*-quinomonomethaneimine (II); but the major product is *o*-benzylaniline. The *p*-isomer behaves similarly; but there is no reaction with the *m*-isomer. The mechanism of these and many related reactions was explained in terms of electron shifts. The reactions are valuable in organic syntheses, especially for the preparation of some simple *o*-substituted benzene derivatives.

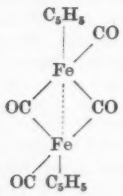


(I) (II) (III)

In the discussion which followed, Dr. G. Baddeley presented evidence that the alkoxyl group is eliminated only if the oxygen atom is free to turn out of the plane of the benzene ring; for example, the *o*-CH_2—O bond is not broken by action of magnesium on (III). Prof. Ziegler also mentioned experience of compounds where elimination does not occur; for example, the reaction of magnesium with $(R\text{O})_2\text{CHCH}_2\text{Br}$ gives the coupled product $((R\text{O})_2\text{CHCH}_2)_2$, provided R is butyl or a higher alkyl group. Dr. E. A. Braude and Dr. N. R. Davies also took part in the discussion.

In describing organo-iron compounds, Dr. M. C. Whiting (University of Manchester) discussed some interesting acetylene complexes derived from iron carbonyl, and the analytical difficulties encountered in establishing their composition. Two distinct types of compounds were described. The first was exemplified by the products of the reaction of phenylacetylene with iron carbonyl in the presence of nickel carbonyl. It is a yellow, crystalline and very stable substance $(PhC{\equiv}C)_2Fe(CO)_4$ isoelectronic with $Cr(CO)_6$. The second series was obtained by reaction of acetylenic substances with iron carbonyl hydride. They are acids, for example, $H_2[Fe_2(CO)_7CH_2C{\equiv}CH]$; but the structure of the anion is unknown. Probably it is similar to that of the uncharged cobalt complex $[Co_2(CO)_6RC{\equiv}CR]$.

Dr. P. L. Pauson (University of Sheffield) gave a historical review of the development of the chemistry of *biscyclo*pentadienyliron (ferrocene) and analogous compounds of the other transition metals. Of the more interesting reactions recently discovered is that of butyl-lithium to give dilithioferrocene, which has a lithium atom in each *cyclo*pentadienyl ring, and those leading to the synthesis of phenylferrocenes up to octa-phenylferrocene. The carbonyl compounds $C_5H_5Fe(CO)_2Br$ and $(C_5H_5)_2Fe_2(CO)_4$ were described. An X-ray investigation indicates that the latter has the structure (IV) in which the C_5H_5 rings are perpendicular to the Fe—Fe bond, and the terminal CO groups perpendicular to the plane of the bridging CO groups.



(IV)

Dr. D. Bryce-Smith (King's College, London) described his investigation of whether free radical intermediates occur in the Wurtz reaction. Wurtz reactions were carried out in the presence of *iso*propylbenzene. Many free radicals react with this compound to form 2 : 3-dimethyl-2 : 3-diphenylbutane by the following reactions:

$$R\cdot + PhCH(CH_3)_2 \rightarrow RH + PhC(CH_3)_2\cdot;$$

$$2\ PhC(CH_3)_2\cdot \rightarrow PhC(CH_3)_2{-}C(CH_3)_2Ph$$

The reaction of *n*-butyl iodide with sodium in *iso*propylbenzene gave, in addition to octane, about 1 per cent of 2 : 3-dimethyl-2 : 3-diphenylbutane, and the yield was similar when *n*-butylsodium was used in place of sodium metal. When lithium or *n*-butyllithium reacted with *n*-butyl halides in *iso*propylbenzene, the yields of 2 : 3-dimethyl-2 : 3-diphenylbutane were 15–20 per cent. Octane was also formed. The fact that 2 : 3-dimethyl-2 : 3-diphenylbutane was not formed by the thermal decomposition of alkyllithium, -sodium and -potassium in *iso*propylbenzene solution indicates that free radicals were not produced, contrary to recent suggestions by Morton and Cluff (*J. Amer. Chem. Soc.*, **74**, 4056 (1952); **75**, 134 (1953)). On the other hand, *n*-butyl radicals, generated in *iso*propylbenzene by the photolysis of di-*n*-butylmercury, gave 2 : 3-dimethyl-2 : 3-diphenylbutane in 50 per cent yield, but only traces of octane. Although free radicals are formed in Wurtz reactions, they probably contribute little to the coupling reaction and are produced in a secondary homolytic reaction between alkyl halide and alkali-metal alkyl.

The organic compounds of lithium and their use in synthesis were admirably reviewed by Dr. E. A. Braude (Imperial College of Science and Technology, London). They offer definite advantages over Grignard reagents. They are more reactive, and their reactions are more free from side reactions, possibly because of the absence of such equilibria as $2RMgX \rightleftharpoons R_2Mg + MgX_2$. They are often easier to prepare, and many organic halides—for example, the vinyl compounds RCH=CHCl—which do not give Grignard reagents, yield lithium compounds. The lithium compounds of the vinyl derivatives retain their configuration about the double bond; thus *cis*-RCH : CHCl yields *cis*-RCH : CHLi. Dr. Braude also described numerous interesting syntheses in the aryl and heterocyclic series of organic compounds where the specific properties of lithium compounds are of especial importance.

It is not possible in the small space available to do justice to Prof. Ziegler's brilliant exposition of his recent researches into the properties of the alkyls of the lighter metals. He first described the pyrolysis of the methyl derivatives of lithium, magnesium and aluminium, then a new series of complex salts formed by aluminium alkyls and finally the use of aluminium alkyls as catalysts in the controlled polymerization of olefins.

The pyrolysis of the heavy-metal alkyls usually gives free alkyl radicals, and of the lighter-metal alkyls, olefins and metal hydrides. The above methyls decompose, however, in neither of these ways. Methane is always a product of the pyrolysis, and in the case of trimethylaluminium a residue of Al_4C_3 remains. Lithium and magnesium methyls yield acetylides; for example, $2\ LiCH_3 \rightarrow CH_4 + Li_2CH_2$, and then at higher temperature $3\ Li_2CH_2 \rightarrow Li_2C_2 + 2\ LiH + 2\ Li + CH_4$. Pyrolysis of such complexes as $LiAlMe_4$ give mixed carbides, for example, LiAlC.

Four types of complex salts derived from aluminium alkyls were described: $Mg[AlR_4]_2$; RMg$[AlR_4]$; $Na[AlR_2F_2]$; and $Na[AlR_2F]$. Salts of the fourth type containing other halogens are stable only in the presence of the larger cations. The first are true salts; but the second do not conduct electricity and may be distilled in high vacuum. The third type, obtained from R_2AlCl and NaF, decomposes on pyrolysis to give $R_3Al + Na_3AlF_6$, and so provides a method of converting R_2AlCl into R_3Al.

In the polymerization of ethylene under pressure at 100–110° C. there are two stages: the growth reaction, $al(CH_2)_nCH_2 + C_2H_4 \rightarrow al(CH_2)_{n+2}CH_2$; and the displacement reaction, $al(CH_2)_nCH_2 + C_2H_4 \rightarrow alCH_2CH_2 + CH_2{=}CH(CH_2)_{n-1}CH_2$ (al = $\frac{1}{3}$ Al). The relative rates of these two reactions determine the length of the polymer chain. The displacement reaction is greatly accelerated by traces of colloidal nickel, poisoning of which is inhibited by phenylacetylene. In its presence smooth conversion of ethylene to butene is achieved. Prof. Ziegler also described schemes for the conversion of ethylene to higher *n*-alk-1-enes, and for obtaining *n*-alcohols from ethylene by oxidation and hydrolysis of the products of the growth reaction. His lecture was followed by an interesting discussion.

J. Chatt

VISCO-ELASTIC BEHAVIOUR

A MEETING of the British Society of Rheology was held during April 29–30 in the Physics Department of King's College, Newcastle upon Tyne. About seventy members and visitors, including some from abroad, met to hear and discuss papers, under the chairmanship of Dr. L. R. G. Treloar, president of the Society.

The flow properties of a system consisting of a mixture of methylmethacrylate and pitch in tar oil were discussed by L. J. Wood and G. Phillips (Coal Tar Research Association). Measurements of viscosity and elastic modulus in the system, and also in one having no polymer added to it, have been made. Both the specific viscosity, defined as the viscosity divided by the retardation time, and the elastic recovery are practically independent of temperature, but markedly dependent on stress. The equilibrium rate of shear and the stress are related by a power law; the apparent viscosity increases as the stress is raised. The elastic recovery can be expressed as $1/e = 1/e_m + b/S$, where e is the elastic recovery, S the stress, b the gradient, and e_m the intercept of the reciprocal recovery/reciprocal stress plot. With increasing polymer concentration from 0 to 2 per cent the value of e_m increases steadily and that of b decreases slightly. Results to date suggest, however, that above this concentration e_m and b remain practically constant.

Dr. A. S. Lodge (Rayon Research Association) outlined a theory of the stresses and birefringence set up in flowing polymer solutions. The deformation of networks is considered to account for most of the viscous stresses observed, and flow birefringence is due to anisotropy of networks. The theory is developed from one which Treloar applied to the rubber-like state and compared with the results of experiments by Signer and by Schmidli.

Dr. K. Weissenberg (Colloid Science Department, Cambridge) demonstrated some interesting experiments, illustrating recent advances in the goniometry of flow, particularly those involving the three-dimensional case of pure shear. For quantitative experiments the material under investigation is contained between two rubber sheets, or within a rubber tube, and the displacements and forces across three mutually perpendicular planes are measured. The conventional technique of testing produced motions of 'simple' laminar shear, and in these the geometry is very complicated because there is a shear-dependent angular deviation between the main axes of the stresses, the strains and their various derivatives in time. The new method of testing resolves this complexity, as it produces motions of pure irrotational shear in which the main axes of all the stresses and strains and time derivatives remain always parallel to one another. The tube formation by rolling of a cylinder has now been established as a phenomenon of great generality which may be regarded as counterpart to the well-known normal pressure phenomenon occurring in elastic and visco-elastic solids and liquids (such as the climbing up of a material on a rotating stirring rod).

Drs. H. Kolsky and F. C. Roesler (Imperial Chemical Industries, Ltd., Welwyn) showed how relaxation spectra may be derived from mechanical measurements on solids. In attempting to correlate the mechanical behaviour of materials with the microscopic processes which cause them, it is desirable to obtain what is termed a 'relaxation–time spectrum' of the material. This treatment postulates that the mechanical behaviour of the solid corresponds to the summation of an infinite number of relaxing elements each with its own time of relaxation, and the spectrum describes the relative strength of these elements. Thus peaks in the relaxation–time spectrum would correspond to the presence of a large number of mechanisms which have characteristic times of values around the peak, and in many cases, especially with metals, it has been possible to correlate these peaks with specific processes taking place in the material.

A number of methods have been developed for the determination of relaxation–time spectra from experimental data and for the conversion of results of one type of measurement into another. The basis of this method is the Fourier analysis of the experimental curve on a logarithmic plot into its separate components. Each component is then multiplied by an appropriate eigen value, and a new curve is thus synthesized. These methods have been tried on a number of published experimental results, and have proved to be extremely effective in dealing with these problems. Recently a numerical iteration method, which avoids the necessity for an explicit Fourier analysis, has also been developed; and while this is not of such wide application as the other approach, in the cases where it may be used it is generally more convenient and may be shown to be equivalent to the more detailed method which employs Fourier analysis.

J. E. Caffyn and L. Goodfellow (Physics Department, Durham) described the mechanical and electrical properties of sodium chloride and made a survey of the effect of mechanical deformation on the electrical conductivity. Apparatus to enable transient electrical phenomena in sodium chloride to be investigated and its application to the study of the changes in electrical properties (particularly conductivity) of ionic crystals were described. Typical results were given for several of the alkali halides, and their variations among different crystals were discussed. A new electrical phenomenon associated with the plastic deformation of the alkali halides and its dependence on temperature was mentioned. Its significance for the earlier measurements was discussed.

Dr. R. Roscoe (Physics Department, Newcastle) spoke of the interpretation of mechanical relaxation in solids. It follows from Boltzmann's principle of superposition that the mechanical behaviour of any material which shows linear visco-elastic effects can be represented in terms of a spectrum of relaxation times or, alternatively, as a spectrum of retardation times. The question arises as to which of these two spectra can be more directly interpreted in terms of the molecular relaxation processes which are ultimately responsible for the visco-elastic effects. It is shown that, when these processes consist in the breaking of linkages in a solid structure, the spectrum of relaxation times for the molecular processes is identical with the retardation time spectrum, provided there is only weak interaction between the individual relaxation processes.

P. J. Kirby (James A. Jobling and Co., Ltd., Sunderland) described results of experiments on 'Pyrex' glass from which the relaxation spectrum over a range of temperature up to the annealing range can be derived. A migration of alkali ions in the vitreous network gives rise to another relaxation process—in electrical conductivity—and the half-

maximum widths of the relaxation spectra are compared with those relating to the visco-elastic effects of the entire network. The distribution of relaxation periods suggests a distribution of the activation energies governing the process. A measure is thereby obtained of the associated distribution of potential barrier heights in the vitreous network. The migration of a network-modifying ion is subject to a wider range of irregularity of activation energy than the general visco-elastic deformation of the network-forming ions.

Drs. A. W. Pryor and E. G. Richardson (Physics Department, Newcastle) have carried out experiments using ferrite transducers of 50 and 100 kc./s. excited magnetostrictively to send torsional waves down long rods made of metal or glass. By varying the temperature in a container surrounding the rod, and measuring the attenuation and phase-shift of transmitted pulses, the elastic modulus and viscosity of the material of the rod or of a liquid under shear in the container were measured. The absorption is less in solutions of rubber in benzene than in pure solvent. The fact that the absorption in these highly viscous solutions is many times less than those calculated from the classical formula—by substituting the known shear viscosities—can be explained by assuming that the high viscosities are by-passed by associated elasticities (that is, these liquids behave at high frequencies more or less as solids).

ADOPTION OF THE UNIFIED SCREW THREAD BY BRITISH INDUSTRY

REPRESENTATIVES of many branches of the engineering industries, the Service Departments and the nationalized industries met recently at the British Standards Institution, under the chairmanship of Mr. H. A. R. Binney, director of the Institution, to review how far the Unified Screw Thread has, in fact, been adopted in Great Britain. The conference was called in response to many inquiries as to how far and how fast the change-over from the Whitworth Thread has progressed during the seven years since the signing of the "Declaration of Accord" between the United States, Britain and Canada, under which the three countries agreed to accept the Unified Thread.

During the years immediately following the signing of the Accord, several British Standards were developed by the Institution for Unified bolts and nuts, screwing tackle and other details necessary for the implementation of the agreement. In the early stages manufacturers of bolts and nuts were unable to meet all the demands for Unified bolts and nuts; but recently the position has improved. The draft standard for black bolts and nuts in the 'normal' series will soon be issued, and manufacturers now foresee no serious difficulty in meeting any future demands likely to be made upon them. The motor, aircraft, oil and chemical industries and the Atomic Energy Authority have all adopted the Unified Screw Thread, and have found that the change-over has not been nearly as inconvenient as they had thought it would be. One of the major difficulties to be faced is not so much the change from Whitworth to Unified bolts and nuts; but the fact that tapped holes are employed in such a great variety of engineering equipment and that this equipment is produced in a wide range of separate industries which includes many comparatively small firms. The opinion at the conference was that the three key groups which can do most to further progress of the change-over are large organizations, such as the nationalized industries, with their ability to influence the market by the many large orders for equipment which they place; the stockist, who is responsible for supplying small orders to a great number of small firms; and the many small manufacturers, who produce miscellaneous industrial equipment with tapped holes.

Although the rate of the change-over to the new thread has been considerably faster than might have been expected some four or five years ago, the advantages to be achieved by working to a single screw-thread system, particularly one which there is every reason to believe will receive increasing support in the Commonwealth and other overseas markets, are so great as to make it very desirable that the tempo of the change-over should be increased. The British Standards Institution was asked to take such steps as may be appropriate to secure wider publicity for this objective, and it was decided that the conference should meet again in about six months time to review the progress then made.

SUBJECT SPECIALIZATION AND CO-OPERATIVE BOOK PURCHASE IN BRITISH LIBRARIES

IN Library Association Pamphlet No. 12 (pp. 32; 1955), Mr. K. G. Hunt, chief librarian of Hammersmith Public Libraries, contributes a useful survey of schemes in subject specialization and co-operative book purchase by libraries in Great Britain, concluding with a quotation from the second interim report (January 1954) of the Working Party of the Library Association. Mr. Hunt gives first some examples of comprehensive schemes arranged by the universities and special libraries. In London, for example, while each of the specialist hospitals covers its own subject, the University Library is building up a large collection of medical periodicals. At Oxford the book selection committee of the Science Library, on which the departmental libraries are represented, avoids a duplication of expensive specialized scientific works. Most of the examples given by Mr. Hunt are outside the field of science, but for medicine the London School of Hygiene, the Medical Research Council, the Royal College of Physicians, the Royal College of Surgeons, the Royal College of Veterinary Surgeons, the Pharmaceutical Society and the Medical Science Library of University College formed a co-operative group, to which the British Medical Association also is attached; this group attempts to arrange that each library keeps to certain fields and informs the others of changes of holdings of periodicals.

A fairly full account of the Metropolitan Special Libraries scheme, inaugurated in 1948 by London Metropolitan public libraries, follows next in the pamphlet. This scheme enabled its constituent libraries to give a service far in excess of what was previously available and has also contributed towards a solution of the storage problem. Later, in January 1950, the South-Eastern Regional Library Bureau's

scheme came into existence, under which an attempt was made to ensure that all newly published books were bought somewhere in the area. Afterwards, responsibilities under the scheme were assigned according to the resources of each library, and each library was also asked to become responsible for the biographies of persons connected with their special subjects. Later still, schemes were started among the public libraries of the Northern Region, the East Midlands (limited to books in foreign languages), Wales (for certain specialized books), and in April 1954, in the North-Western Region (in which seventy-five libraries participated, but periodicals and purchase of older books are excluded).

Mr. Hunt suggests that the most necessary future developments are likely to be concerned with increasing the provision of foreign books, and co-ordinating and improving the supply of periodicals. Such problems are mainly the concern of university and special libraries; but the various regional schemes of public library co-operation could easily be co-ordinated and improved by dividing the responsibilities for still higher degrees of specialization between the specializing libraries in each subject in each region on a systematic and orderly basis. This would give strong support to any co-ordination attempted by research institutions acting alone.

AMERICAN PHILOSOPHICAL SOCIETY

YEAR BOOK FOR 1954

THE Year Book for 1954 of the American Philosophical Society* includes E. G. Conklin's brief history of the Society, its charter and laws, reports of standing committees, and the usual lists of members and biographical memoirs, among which may be noted those of M. T. Bogert, Sir Henry Clay, K. T. Compton, H. E. Ives, T. Lyman, R. A. Millikan and H. A. Spoehr. The report of the Committee on Research lists 165 grants, totalling 144,770 dollars, and one conditional grant of 600 dollars, made during the year from the Penrose Fund. Six of these, totalling 8,300 dollars, were in astronomy, physics and chemistry; thirty-six, totalling 29,195 dollars, in zoology, botany, anthropology, biochemistry, physiology, psychology and related sciences; forty, totalling 37,755 dollars, in history, political science, economics and sociology; and eighty-three, totalling 72,520 dollars, in ancient, medieval and literary history, archæology, philology, art, literature, etc. Eight grants, totalling 21,336 dollars, were made from the Johnson Fund and six grants, totalling 13,335 dollars, from the Daland Fund for Research in Physical Medicine.

Reports from recipients of grants occupy some two hundred and fifty pages of the report of the Committee on Research. Among the more detailed of these summaries may be noted those of H. B. Levi on recent progress in the field of radiocarbon dating; M. K. Hecht on the comparison of recent and fossil amphibian, reptilian and mammalian faunas in the Bahamas; A. Carr's survey of the zoogeography and migrations of sea turtles, which indicates that under present conditions the green turtle is likely to be extirpated from the Caribbean within twenty years although it appears to be peculiarly amenable to conservation; K. T. Guthe's study of the myosin adenosine triphosphate of the echinoderm *Stichopus*; and C. J. Heusser's studies of glacier fluctuation, forest succession and climatic variation in the Canadian Rockies and pollen profiles from the Queen Charlotte Islands, northern Vancouver Island and northern coastal British Columbia. R. Singer reports on studies of the Basidiomycetes of South America in European herbaria, and J. L. Angel on the evidence as to human biology, health and history in Greece obtained by careful study of human bones excavated in Greece; M. J. Herskovitis reports on field work in sub-Saharan Africa to assess how pre-existing cultural patterns react to different rates of industrialization and technological innovation, within the limits of differing Colonial policies, while W. B. Schwab discusses the analysis of material collected in a socio-economic survey of the Yeruba community in Nigeria with the object of examining the interrelations of urbanization and acculturation.

D. R. Brown summarizes an investigation of the effects on cortical currents of organic damage to the brain by the use of a behavioural measure involving the kinesthetic figural after-effect which appears to support the assumption that the lesion introduced in a lobotomy sets up a temporary physiological disturbance in the cortex which will change the conductivity of the higher brain centres and therefore the kinesthetic after-effect. W. S. Verplanck describes an interchange of experimental techniques and theoretical structures between European ethologists and American psychologists; and L. S. Ciereszko gives an account of the determination of vanadium in tunicates and of acidity in *Ascida nigra* as well as the collection, identification and preparation of various tunicates, sponges and gorgonians. N. C. Li reports on metal complexes of peptides containing sulphur, H. W. Neuberg on the metabolism of phosphophenolpyruvate, F. W. Crane on the spores of *Dryopteris*, and G. T. Johnson on the Mississippi species of the Trypetheliaceae.

In the social sciences, D. W. Meinig describes and analyses the nature of man's contact with the major agricultural frontier of the Pacific north-west and the Columbia Plateau grain region from 1805 to about 1910, and C. T. Mason an inquiry into the non-profit research institute and how it functions. In archæology, H. A. Carey reports on a study of the ancient Indian culture centring in the Casas Grandes Valley, north-west Chihuahua, Mexico; F. E. Day on early Islamic pottery related to that of Tarsus and 'Arija Hafir'; K. P. Kent on the textile industry of prehistoric south-western Pueblo peoples, particularly with regard to weaving in cotton; R. S. MacNeish on the development of agriculture and the concomitant development of civilization in Meso-America, Tamaulipas, Mexico; H. C. Palmatary on Brazilian, Swedish and American Tapago pottery; and A. N. Stilwell on pottery from the Potters' Quarter in Corinth. P. Drucker describes a study of intertribal organizations of the north-west coast of the United States, I. Greenwald a study of the history of goitre, and C. Eisele one of C. S. Peirce and the history of science. Investigations of the freshwater ostracods of South Carolina are described by E. Ferguson, taxonomic and ecologic researches on the ants of Nevada by A. G. Cole, and a detailed field study of spring Orthoptera in western and south-western States by J. A. G. Rehn.

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FINE STRUCTURE OF CELLULOSE AND OTHER MICROFIBRILLAR SUBSTANCES

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THE sub-microscopic structure of matter has long been investigated by deducing it from the manner in which it scatters either electromagnetic or particle rays. A method of stating this relation in a most elegant form is offered by the Fourier transform which is sufficiently general to include scattering of electrons as well as of X-rays. X-ray crystal structure analysis, however, cannot be employed when we have wave-lengths much shorter than 0·5 A., since incoherent scattering, which is not governed by the Fourier transform, becomes dominant. For these shorter wave-lengths recourse has to be made to electron diffraction. Electron diffraction diagrams of *Valonia* cellulose have already been published from this laboratory[1], and it is the purpose of this article to examine some of the features of these diagrams which were not discussed at that time.

Hettich[2] pointed out that the transform of any group of atoms will describe the contribution of that group to the total scattering from any crystal in which it may occur. Transforms of molecules which consist mainly of parallel hexagons have one feature in common: they all tend to have hexagonal symmetry[3]. Since for a periodic structure, that is, a crystal, the transform reduces to its own weighted reciprocal lattice, the latter often exhibits symmetry of the transform which can be observed on the diffraction photograph. Electron diffraction diagrams of *Valonia* cellulose show a fairly well-developed hexagonal shape of the pattern (Fig. 1). The orientation of this hexagonal distribution of reflexions

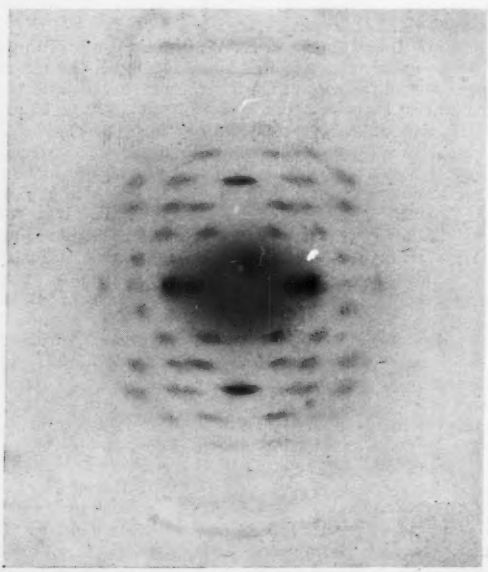

Fig. 1. Electron diffraction diagram of a single set of microfibrils of *Valonia* cellulose. Note the hexagonal shape of the pattern and the low intensity of the first and seventh layer lines

Fig. 2. Electronmicrograph of *Valonia* cellulose microfibrils in correct orientation with respect to Fig. 1 (× 30,000; shadowed Pd—Au)

with respect to the direction of the microfibrils (Fig. 2) indicates that the glucose residues are arranged in such a way that two sides of the glucose residue rings are oriented approximately parallel to the fibre axis. This confirms, therefore, the orientation assumed in the commonly accepted structure of native cellulose[4,5].

The same electron diffraction photographs show also very prominently the effect of thermal motion of the cellulose chains. Since the wave-lengths used in these observations are about twenty times shorter than that of copper $K\alpha$ radiation, the intensities of diffracted rays are much more sensitive to molecular and atomic movement. The thermal vibration of the atoms is mainly shown in the direction perpendicular to the length of the chain, longitudinal waves in the direction of the chain-length being negligible. Thus the reflexion from the planes which are parallel to the chain-length fades away at much smaller Bragg angles than do the reflexions due to planes normal, or nearly normal, to chain-lengths.

At present, using the Philips electron microscope, it is possible to record nine layer lines above and below the equator. It is important to note that the distribution of intensities among the layer lines is such that, apart from very low intensity planes of the type $\{h11\}$, there is another similar group of planes $\{h71\}$. This phenomenon, being closely connected with the atomic architecture of the unit cell of cellulose, is a valuable guide in the refinement of the structure of native cellulose.

In contrast with the X-ray method, the amount of scattering material used in electron diffraction is enormously decreased, and thus the chance of having all scattering crystalline regions oriented in very nearly the same way is much higher. As a consequence the reflexions appear as fairly sharp spots. In fact, the electron diffraction pattern of native cellulose has more resemblance to a single crystal oscillation-rotation picture than to a fibre photograph.

The atomic scattering power in the diffraction of electrons is about 10^3 times higher than for X-rays. Hence, although the collimating system has very

Table 1

Microfibrils	Thickness in A.	Authority
Valonia cellulose	*c.* 200	Preston[7]
Ramie cellulose	100	Mühlethaler[11]
Hemp cellulose	100	"
Cotton cellulose	100	"
Bacterial cellulose	100	Franz and Schiebold[13]
Tunicin cellulose	250	Frey-Wyssling and Frey[12]
Baker's yeast	250	Houwink and Kreger[14]
Silk fibroin	above 100	Hegetschweiler[15]
Fibrous insulin	100	Farrant and Mercer[16]
Deoxyribonucleoprotein	90–120	Elmes and White[17]
Flagella of *Proteus vulgaris*	120	Astbury[18]
Tropomyosin	250–300	Astbury, Reed and Spark[19]
Actomyosin	120	Astbury[20]; Perry *et al.*[21]
Rod-like bodies of tobacco mosaic virus	150	Bernal and Fankuchen[22]
Vanadium pentoxide strands	200	Mühlethaler[23]
Crysotile (Italy)	220	Fankuchen and Schneider[24]
'Harsh' crysotile (U.S.A.)	250	" " "
Canadian crysotile	200	" " "

Table 2

Miscellaneous	Thickness in A.	Authority
Carbon soot	200–300	Ardenne and Hofmann[25]
γ-FeOOH particles	100	Fricke, Schoon and Schröder[26]
α-Fe_2O_3 particles	100–200	" "
Iron airsol particles	100–200	Beischer[27], Ardenne[28]
Flakes of $Mg(OH)_2$	100	Marx and Wehner[29]
Liquid helium II film	190–220	Burge and Jackson[30]
Liquid helium II film	170–220	Atkins[31]

narrow openings and the distances between specimen and film in the electron microscope are of the order of tens of centimetres, the exposure time is usually a fraction of a second. On the other hand, the electron beam, being so strongly scattered, can pass through very thin layers only. From the formation of the spot pattern on the electron diffraction photograph of cellulose it follows that the thickness of the crystallites in the single layer of the cell wall of the alga *Valonia* is about 100–500 A.[6].

These numerical values lead to rather important conclusions. In the course of an investigation of the structure of the cell wall of *Valonia* it was shown[7] that microfibrils forming the cell wall are of width 200 A. More accurate data[8] obtained in 1951 revealed that the microfibrils vary in width from about 100 A. to about 350 A. and are flattish ribbons with the thickness to width ratio lying somewhere between 1/3 and 1/7. Comparison of the thickness of the crystallites derived from the electron diffraction pattern (from the single layer of *Valonia* cell wall) with the width of the microfibrils indicates strongly that the latter are in fact almost pure crystalline rods. It seems probable that the same considerations could be applied to all those algae in which the wall architecture resembles that of *Valonia*[9]. As has already been pointed out[8], it may not be concluded that the microfibrils of all celluloses are single crystals; on the contrary, it is clear that in bacterial cellulose and the celluloses of higher plants the internal structure may be of the general type figured by Frey-Wyssling[10], that is, with a lower degree of crystallinity.

Investigation along these lines concerning the fine structure of the crystalline state of native cellulose is continuing. The observation, however, that the microfibrils of cellulose are of the same order of diameter irrespective of their internal structure leads irresistibly to the speculation that there might be something special about dimensions centring roughly around 200 A. It is interesting, therefore, to note the order of size of various fibriform bodies (visible in the electron microscope), and we present in Tables 1 and 2 some of the data we have found in the literature. This is to direct attention to the remarkable similarity in size between the finest units visible in a number of substances of very different chemical constitution. We do not at the moment wish to comment further, nor indeed are we perhaps capable of usefully doing so; but it would seem reasonable to suggest that there may be some principle of structure conferring special stability in fibres or sheets about 200 A. thick. The microfibril of cellulose might then be not a biological unit, as we had thought, but a thermodynamic one. [May 4

Note added in proof. Since the above communication was presented, our attention has been directed to an article by R. Fürth (*Exp. Med. Surg.*, **13**, 17; 1955) on the theoretical implications of fundamental dimensions in biological material.

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SYMMETRY OF THE SECOND EXCITED SINGLET STATE OF BENZENE

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ALL π-electron theories have agreed in assigning the first singlet excited state of benzene, that responsible for the band-system at 2600 A., to the trigonally symmetrical species B_{2u}; and this assignment has since been fully established by experiment[1]. However, agreement between the different theories does not extend to the second excited singlet state—

that involved in the band system at 2000 A. Moreover, the nature of this state has not yet been made clear on experimental grounds, though the importance of the question, as the simplest crucial test of π-electron theories, is widely recognized.

This second state was originally assigned to the other trigonal species B_{1u}, in 1938, by Goeppert-Mayer and Sklar[2], on the basis of a calculation of benzene energy-levels by the method of molecular orbitals. In 1950 Craig extended this method outside its basic framework of the direct description of each molecular state in terms of a specified configuration of electrons in molecular orbitals, by computing the effect of configuration interaction, that is, resonance between the various possible distributions of electrons among orbitals[3]. On this broadened basis, Craig found the second excited level of benzene to belong to the degenerate class E_{2g}, the trigonal B_{1u} level lying considerably higher. Also in 1950 he showed that the valency bond method, when extended within its own framework by the inclusion of polar structures[4], as is particularly necessary for the discussion of excited states, which are for the most part strongly polar, also gave the second excited state as an E_{2g} state, the B_{1u} state again lying considerably higher. The valency-bond method, though it employs bond orbitals rather than molecular orbitals, is essentially a resonance, or many-configuration, method; and so it appears to be the typical result of resonance among many electronic distributions that the degenerate E_{2g} level of benzene lies lower than the trigonal B_{1u} level. Since 1950, a number of authors[5] have continued to support the first assignment on the ground that, although Goeppert-Mayer and Sklar's form of the molecular orbital theory was not wholly satisfactory, other forms of it, particularly semi-empirical modifications, would have less need for account to be taken of configuration interaction, and so would continue to give the typical single-configuration result that the B_{1u} state lies lower than the E_{2g} state.

Here, then, is a clear issue; but in treating it, one must keep in mind such other alternatives as cannot already be shown to be impossible, even if they might appear improbable. One such possibility has been suggested[6]; and it is that the second singlet band-system of benzene constitutes the first member, with $n = 3$, of the allowed Rydberg series of states $2p\pi \rightarrow ns$. This implies an upper A_{2u} state; and the diagnostic feature of the proposal is that such a transition must be polarized perpendicularly to the aromatic plane. However, Craig and Lyons made it very probable, by reference to the corresponding band-system of hexamethylbenzene, which they studied with polarized light in the layer-plane crystal of that substance[7], that the main intensity of the system is polarized in the aromatic plane. All pure π-type non-ionizing transitions must be polarized in the aromatic plane. This evidence is strong, but not perfectly conclusive, because the magnitude of the spectral disturbance, due to crystal forces, can only be roughly estimated; but we do not believe that it could be large enough qualitatively to invert the conclusion drawn. A subsidiary argument is that such Rydberg bands would be expected to be sharp. The bands of the system at 2000 A. are far from sharp. However, certain π-type transitions contain in their own nature a cause of band diffuseness, apart from any diffuseness that might be imposed on them by external perturbation.

We shall keep in mind also some just conceivable interpretations of the second band-system which have not been suggested before. One is that it may be a π-type transition to a forbidden, partly polar E_{1u} state, calculated by the valency-bond method[4] to lie next above E_{2g} (and not to be confused with the allowed, fully polar E_{1u} state, which lies higher still). Another assumes that some current assignments of higher Rydberg terms, which are not fully proved, are incorrect, thus allowing our state to be a forbidden *s*-type Rydberg state of symmetry E_{1g}. But the convenient procedure is to keep all such ideas in reserve, for a subsequent consideration of any modifying effect they may have on the conclusion to be drawn from an attempt first to treat the question of assignment as a straight issue between the contrary indications of single-configuration and resonance theories. So we first set down the expected spectral characteristics of transitions to the states B_{1u} and E_{2g}.

Transitions from the ground-state to a B_{1u} state are forbidden, but can occur, along with a one-quantum change in that ε_{2g} vibration which involves radial motion of the CH groups (frequency 605 cm.$^{-1}$ in the ground-state)[8]. There should be a main progression towards short waves in successive quanta of the upper-state ring-breathing vibration α_{1g} (frequency 990 cm.$^{-1}$ in the ground-state). There should also be a similar, but temperature-sensitive, Boltzmann progression, shifted by about 1,100 cm.$^{-1}$ to long waves, and about fifteen times weaker than the main progression at room temperature. The bands should be sharp, apart from any effect of external perturbations. In short, a B_{1u} band-system at 2000 A. should closely resemble the familiar B_{2u} band system at 2600 A., for which, indeed, a B_{1u} assignment was at one time suggested[9]. An addition to this description is made later.

Transitions from the ground-state to an E_{2g} state are forbidden, but can occur in association with a one-quantum change in a β_{1u}, β_{2u} or ε_{1u} vibration, most strongly with such a change in the β_{1u} vibration of CH groups (frequency 1,010 cm.$^{-1}$ in the ground-state)[8]. The total consequences are somewhat complicated, and so we describe them in successive approximations. The first approximation is that there should be a main progression towards short waves in the ring-breathing vibration of the upper state, but that the corresponding Boltzmann progression would be difficult to observe, as it would be more than a hundred times weaker, and displaced to long wave-lengths by about 1,900 cm.$^{-1}$, thus originating in the observable tail of the B_{2u} band-system.

Our second approximation starts from Jahn and Teller's proof[10] that every non-linear molecule which is sufficiently symmetrical to permit degenerate internal motion will have a normal co-ordinate with the property that, in a degenerate electronic state, the energy will be minimized at a non-zero value of the co-ordinate, with the result that the original equilibrium symmetry will be lost, and the degeneracy of the electronic motion will be split. It is easily shown that, in benzene, the active normal co-ordinate is one of those belonging to the already mentioned ε_{2g} vibration; in particular, that one which flattens the hexagon vertically or horizontally by pulling apart or pushing together two opposite sides, thus reducing the symmetry from D_{6h} to V_h. It is to be concluded[11] that the nominal E_{2g} state will actually consist of the two, energetically separate, but close-

lying states, A_g and B_{1g}, appropriate to the lower symmetry; and that each of these will have, as its equilibrium nuclear configuration, a different flattened hexagon of symmetry V_h, the two flattened hexagons being interconvertible by the ε_{2g} vibration. This has two immediate spectral consequences. First, because of the larger number of vibrations that are now totally symmetrical with respect to the reduced nuclear symmetry, our simple progression will become a compound one, involving combinations of different vibrations, especially the ring-breathing vibration (corresponding to α_{1g} of frequency 990 cm.$^{-1}$ in the ground state), which allows ring-size to change on excitation, and the ring-flattening vibration (corresponding to ε_{2g} of frequency 605 cm.$^{-1}$ in the ground-state), which, by converting the original regular hexagon into either flattened hexagon, allows ring-shape to change on excitation. Secondly, the whole of this compound progression should be doubled, with a separation of the order of magnitude of a vibration frequency[11], because of the doubled electronic origin.

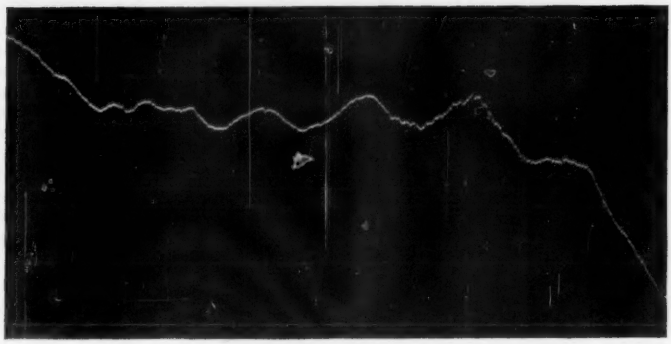

Fig. 1. The 2000 A. band-system of benzene vapour

A third approximation is necessary in this description, for the reason that the relatively small magnitude of the Jahn–Teller electronic splitting will cause a breakdown of the Born–Oppenheimer approximation, which normally allows each electronic state to have its own vibrations. This has two further spectral consequences. The first is derived from the circumstance that any vibration that could interconvert the flattened hexagons will belong in principle to both states, and will act as a vibration controlled by a potential with two unequal minima separated by a low barrier. We therefore expect our compound progression of doubled bands to break up at various points, depending on the interconverting vibrations concerned, into a series of single bands about twice as closely spaced. A very few quanta of the ring-flattening vibration, which is best suited to effect the change of shape, could bring about such a break-up; but more quanta of the ring-breathing vibration would be needed, inasmuch as change of shape on its account depends on the differences of amplitude of the radially moving carbon atoms. The second spectral consequence follows from the consideration that vibration will become coupled, not only with electronic motion, but also with rotation, because conserved angular momentum, quantized totally, and about the axis of a symmetrical top, but not about the axes of asymmetrical tops, and carried by degenerate vibrations in a symmetrical top, and by electronic motion and rotation in this, and in our interacting asymmetrical tops, will be shifted about between these carriers during excitation to the double state described. We can see here plenty of cause for expecting all bands to have a smooth appearance.

A final point can now be added to our theoretical description of a B_{1u} band-system. The intensity of the system at 2000 A. is obviously stolen from the shorter-wave allowed system, involving the upper state E_{1u}. This is degenerate, and must suffer Jahn–Teller splitting. It follows that a B_{1u} system at 2000 A. should, in its main progression, but *not* in its Boltzmann progression, exhibit a pale reflexion of the consequences of this degeneracy, by showing a narrow splitting, and a little smoothing of the bands. These effects should be small compared to those arising from an upper state, such as E_{2g}, to which degeneracy is indigenous.

Experimental study of the band-system at 2000 A. is, indeed, made difficult by the smoothness of the bands, and the consequent impossibility of securing frequency differences of the accuracy desirable for vibrational analysis. However, our study of the system includes an attempted analysis. We conclude that no analysis is possible on the basis of a B_{1u} upper state, but that a plausible analysis can be given on the assumption of an E_{2g} upper state.

The band-system has been described several times before[12]; but we reproduce a general microphotometer record of it as a reminder of its overall form (Fig. 1). We see a widely spaced progression of strong bands, breaking up at the fourth quantum into a series of closer, moderately strong bands, and carrying, from the first onset of strong absorption, a superposed ripple of closely spaced weaker bonds, which at higher energies die away. All bands are smooth, and, so far as can be seen, are shaded in both directions. None of the bands mentioned appears to be weakened by cooling. Little can be seen of any Boltzmann progression in the long-wave region. This remains true on heating.

So different is this appearance from that of the familiar B_{2u} system, at 2600 A., that we think it unnecessary to elaborate the thesis that any attempted analysis of the present system on the basis of a B_{1u} assignment is bound to fail. In particular, there are no Boltzmann bands remotely approaching the strength of those required for a B_{1u} assignment in, or anywhere near, the expected region.

Although we have not the confirmation which might follow could we measure accurate frequency differences, the general lines of an analysis based on an E_{2g} assignment can be given. The two vibronic origins demanded by Jahn–Teller splitting are identified with the first two bands at the onset of strong absorption, the first at 49,065 cm.$^{-1}$ and the second at 49,215 cm.$^{-1}$; the splitting thus amounts to 150 cm.$^{-1}$. The frequency of the first quantum of the ring-flattening vibration is taken as about 320 cm.$^{-1}$ in either state; and we account for the smallness of this value, compared to the corresponding ground-state frequency, 605 cm.$^{-1}$, by supposing that, although the zero-point levels in the split states are separate, even one quantum of this

vibration will mix the electronic states. This vibration is totally symmetrical with respect to the deformed hexagons, and therefore is allowed to appear with successive quantum numbers. Consistently, we find it appearing with one, and then with a second quantum in each split state, or, putting it more correctly, with four successive quanta in the interacting pair of states. Then a quantum of the breathing frequency, taken to be about 900 cm.$^{-1}$ in either state, supervenes, leading to a strong maximum, doubled because of the two vibronic origins. After that, the pattern of weak bands repeats itself, gradually fading out over the next two strong bands, which represent the addition of a second and a third quantum of the breathing vibration. About here, the breathing frequency begins to show very strong anharmonicity; and immediately thereafter the breathing progression breaks up into more closely spaced, but apparently simpler, bands, which can be followed into the bank of intensity leading to the next band-system. We explain the sudden incursion of strong anharmonicity, and the immediately following break-up of the progression, by assuming that four quanta of the breathing vibration suffice to cause full mixing of the split electronic states.

In the long-wave region, only one Boltzmann band of more than very small strength has been observed; but it is very difficult to measure, being so overlapped in the first onset of strong absorption. Our measurements place it 275 cm.$^{-1}$ below the first maximum at 49,065 cm.$^{-1}$; but, because of the overlap, this estimate could be wrong by 50 cm.$^{-1}$. The only Boltzmann band which might be predicted from the E_{2g} electronic assignment, to have sufficient strength and separation from main bands for fairly easy observation, would occur in this region. It is the $1 \rightarrow 1$ transition of the ring-flattening vibration; for, although $1 \rightarrow 1$ transitions in all vibrations are allowed by symmetry, no vibration other than this could have, at once, so large a Boltzmann factor, so large a frequency difference between upper and lower states, and a transition probability so favoured on Franck–Condon grounds. Because of the two vibronic origins, this $1 \rightarrow 1$ transition should produce two bands, situated, according to the figures already given, 140 and 285 cm.$^{-1}$ below the maximum at 49,065 cm.$^{-1}$. The first of these would be completely buried in the strong band; but the second could be the much overlapped band we have measured, 275 cm.$^{-1}$ below the first maximum.

The only other Boltzmann bands the presence and approximate location of which seem certain are two (at least) extremely weak bands near 850 and 1,000 cm.$^{-1}$ below 49,065 cm.$^{-1}$. They are not overlapped; but their extreme weakness makes measurement difficult. Two interpretations are possible, one depending on, and the other independent of, the electronic assignment. The strongest (though still very weak) Boltzmann progression that should be characteristic of an E_{2g} electronic state is that which involves one quantum of the ground-state frequency 1,010 cm.$^{-1}$ throughout, and, in the upper state, a succession of quantum-levels of the breathing vibration. Each member of this progression should consist of a pair of bands 150 cm.$^{-1}$ apart; but the first member of the progression would be mixed with the tail of the long-wave B_{2u} band-system; and the third and higher members would be under the strong bands of the band-system now under discussion. The one member that we might hope to find is the second, for the two reasons that it alone would not be overlapped and that it would be the strongest member of its progression, just as the second member is the strongest in the main ring-breathing progression. This second Boltzmann member would be represented by a pair of bands in about the positions in which ours are observed. However, any electronic assignment would permit a very weak Boltzmann progression involving one quantum of the ground-state frequency 990 cm.$^{-1}$, and a succession of quanta of the upper-state breathing vibration. The second and higher members of this progression would be buried under strong bands; but the first member would not be overlapped, and would consist of a pair of bands approximately where ours are observed. These two bands are too weak and diffuse to belong to the main Boltzmann progression of a B_{1u} system, which should consist of single, sharp and fairly strong bands.

Turning to the electronic assignments held in reserve, an interpretation of the system as one of the forbidden π-state E_{1u}, or of the forbidden Rydberg s-state E_{1g}, must fail, for one of the reasons for which the B_{1u} assignment fails, namely, all these assignments require easily observable Boltzmann bands, where none can be found. Interpretation as a system of the allowed Rydberg s-state A_{1u} fails among the main bands: it cannot account for the doubling, the ripple and the break-up; and it disagrees with Craig and Lyons's probable identification of the direction of polarization. Thus we are unable to suggest any type of upper state, other than E_{2g}, on the single basis of which all the chief features of the spectrum can be understood. Of course, this does not mean that some other electronic state, perhaps one of the others considered, may not be responsible for a minor part of the intensity or even for some of the spectral appearance near the high-energy limit, where our system merges with the next strong system.

It is our provisional conclusion, therefore, that the second excited singlet π-state of benzene has the symmetry E_{2g}, in agreement with configuration interaction and valency bond theory, but contrary to single-configuration molecular orbital theory, in all its proposed forms. Further details of this work, and an account of some supporting investigations on hexadeuterobenzene, and on some halogen substituted benzenes, will be given elsewhere.

This investigation has benefited much from theoretical suggestions by Prof. D. P. Craig, and from exploratory work by Dr. L. E. Lyons. One of us (T. M. D.) wishes to acknowledge the receipt of a Science Scholarship from the Royal Commission for the Exhibition of 1851. [Feb. 18

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LETTERS TO THE EDITORS

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Isolation and Properties of a Collagen soluble in Salt Solution at Neutral *p*H

THE presence of a soluble type of collagen in skin, extractable with slightly alkaline phosphate buffers, has been reported by Highberger *et al.*[1]. On the basis of their studies of the metabolism of collagen in rabbit skin, Harkness *et al.*[2] have concluded that this protein is almost certainly a direct precursor of mature collagen and have called it 'alkali-soluble collagen'. The isolation procedure of Highberger *et al.* involved purification by solution in citrate buffer of *p*H 3·8 and dialysis against distilled water; but the final product was no longer soluble in either neutral or alkaline buffers used for the original extraction. It thus seemed likely that the physical properties of alkali-soluble collagen had been altered during isolation. We report here a new method of isolation and preliminary studies of some of the physical properties of the isolated protein.

The material was extracted from the skins of young rabbits with *M*/15 phosphate of *p*H 7 and precipitated by addition of sodium chloride to a final concentration of 16 per cent. Purification was carried out by repeated solution in phosphate and precipitation with sodium chloride or ammonium sulphate. The isolated material had a hydroxyproline content of 8·2 per cent (expressed as amino-acid nitrogen per cent total nitrogen) and very low tyrosine content. It had a low solubility, approximately 0·2 per cent, in *M*/15 phosphate of *p*H 7.

Ultracentrifuge studies were made at 26° and 7° C., viscosity and birefringence measurements at 4° C., on solutions containing 0·02–0·09 gm. per cent in *M*/15 phosphate of *p*H 7·4. The schlieren diagram given in the ultracentrifuge showed a single sharp peak, without any evidence of gross heterogeneity. The sedimentation coefficient S_{20}, corrected to water at 20° C., varied considerably with the concentration c (gm. protein per 100 ml. solution); $d(1/S_{20})/dc$ was constant at 1·68, and S_{20} extrapolated to infinite dilution was 3·23 Svedberg units. The relative viscosity ($\eta_{rel.}$) measured in a Couette viscometer increased markedly as the velocity gradient was decreased below 5 sec.$^{-1}$. At zero velocity gradient, $(\eta_{rel.}-1)/c$ was 47 and did not change appreciably with concentration. Using Ogston's[3] method for a spheroidal particle, the following dimensions were derived: particle weight $\sim 10^6$, axial ratio 40, length 5,800 A. and an apparent hydration of 40 ml./gm. Birefringence measurements indicated a particle-length of about 4000 A., but showed that the material was not homogeneous. The ultracentrifuge schlieren diagram did not exclude inhomogeneity. The values are only approximate, but definitely indicate elongated particles. Electron micrographs made by Mr. R. Valentine of a solution of the material fixed on the grid by osmium tetroxide vapour and shadowed with platinum–palladium showed fine fibres of varying lengths. Material fixed in formalin, disintegrated by ultrasonic vibration and stained with phosphotungstate showed similar fibrils about 100 A. in diameter, and these were banded, with principal repeat units of about 2200 A. and 5000 A. (Fig. 1). This suggests that the material existed in solution as various linear aggregates of a unit of several thousand angstroms.

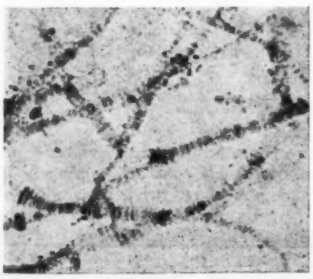

Fig. 1. Neutral salt-soluble collagen. Preparation as in text. ×150,000

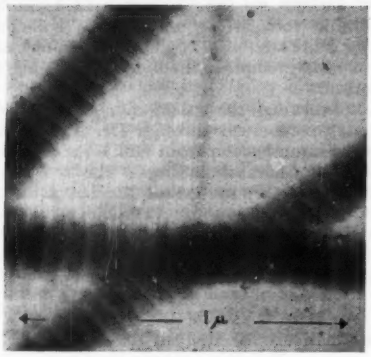

Fig. 2. Fibres formed at 5° C. from a solution containing 0·03 gm. per cent of neutral salt-soluble collagen, *p*H 7·2. Phosphotungstate stained. × 50,000

On keeping solutions in various buffers at temperatures between 4° and 37° C., up to 80 per cent of the material was precipitated. This precipitate has been provisionally called 'heat-precipitated collagen'. The time taken for a precipitate to appear varied from seconds to weeks according to conditions. Between *p*H 6·5 and 7·4, the reciprocal of this time varied directly as the hydrogen ion concentration and also varied with the concentration of starting material. The logarithm of the reciprocal precipitation-time was approximately proportional to the reciprocal of the absolute temperature.

When the precipitate formed slowly, it consisted of fine fibres directly observable in the optical microscope and readily stainable with van Gieson connective tissue stain. Electron micrographs of the heat-precipitate stained with phosphotungstate show banded fibres of up to 2000 A. diameter with a major repeat distance varying from 580 A. to 800 A. in different fibres (Fig. 2). Various patterns of substriations, one 'polarized' in the direction of the fibre, are seen.

The appearance was quite different from that of neutral salt-soluble collagen, in which lateral aggregation did not exceed 100 A.

Preliminary studies indicate that heat-precipitated collagen is similar to acid-soluble collagen in that it is soluble in dilute acetic acid and citrate buffers, and has a similar appearance under the electron microscope. The transformation of neutral salt-soluble collagen to heat-precipitated collagen may

then be similar to the *in vivo* transformation of alkali-soluble collagen to acid-soluble collagen suggested by Harkness *et al.*[3]. This possibility and the nature of heat-precipitated collagen are being further investigated.

After observing the phenomenon of heat precipitation, we received through Dr. A. Neuberger a personal communication from Drs. Gross, Highberger and Schmitt of similar findings; this work has now been published[4]. We are grateful to Dr. A. Neuberger and Dr. A. G. Ogston for valuable advice and to Mr. R. Valentine for the electron micrographs.

This work was financed by the Medical Research Council and by the Nuffield Foundation.

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Sorption Chromatography of Polar Substances on Polyamides

Linear polyamides, in the form of fibres or fine powders, are able to absorb polar substances from solution[1], with the formation of hydrogen bonds. The sorption is restricted to the amorphous regions, where a solution process of the polar substance into the polymer takes place. The Flory–Huggins relation[2]:

$$\ln a_1 = \ln v_1 + (1 - 1/x)\, v_2 + \chi_1 v_2^2 \qquad (1)$$

has been found[1] to hold, when the volume fractions v_1 and v_2 of the polymer and the polar substance are corrected for the degree of crystallinity of the polymer.

The amount of a polar substance which can be absorbed at equilibrium by a unit weight of polymer (which is related to v_1 and v_2) therefore depends upon a number of factors. These are: (i) the chemical potential of the substance at a given concentration of solution (which is related to its activity a_1 in the polymer); (ii) its thermodynamic interactions with the polymer (which are expressed by the semi-empirical parameter χ_1); and (iii) the degree of crystallinity of the polymer.

The sorption isotherms of very similar compounds have been found to show marked differences, and substances containing groups which are able to form strong hydrogen bonds with the amide groups of the polyamides are absorbed to a very large extent. These observations have turned our attention to the possibility of using polyamides as absorbents for chromatographic separation of polar substances. Experiments undertaken in this direction have so far given promising results.

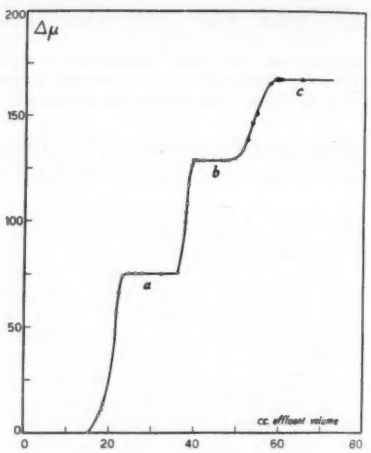
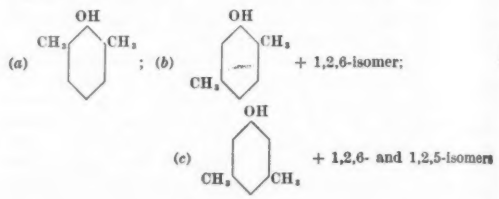


Fig. 1. Frontal chromatography of a mixture of three isomeric xylenols:



Two examples will be given here of absorption chromatography of compounds belonging to an isomeric group and to a homologous series. The first example deals with the frontal chromatography of a mixture of three xylenols, namely, the 1,3,5 (m.p. 68° C.; b.p. 219° C.), the 1,2,5 (m.p. 74° C.; b.p. 211° C.) and the 1,2,6 (m.p. 49° C.; b.p. 212° C.) isomers, all of which have very close physical constants. The second example deals with the frontal chromatography of a mixture of propionic acid, butyric acid and caproic acid.

The experiments were carried out in a Tiselius–Claesson apparatus of the *L.K.B.* type. A solution in *cyclo*hexane of the compounds to be separated was forced through a short column filled with a tightly packed powder of polyhexamethylene adip-

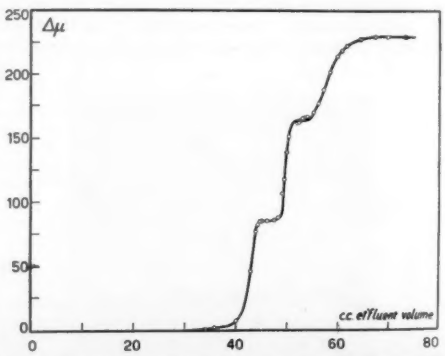


Fig. 2. Frontal chromatography of a mixture of propionic, butyric and caproic acids

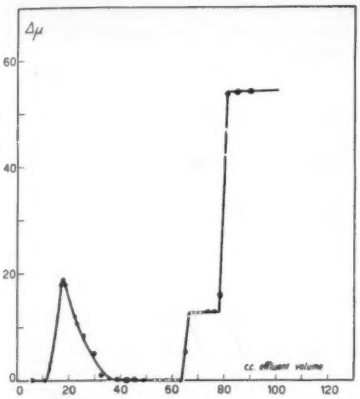


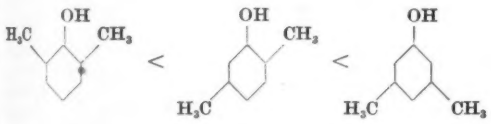
Fig. 3. Displacement chromatography of a mixture of 1,2,5- and 1,2,6-xylenols, using the 1,3,5-isomer as a displacer

amide obtained by precipitating the polymer from a concentrated solution in formic acid by the addition of a water–alcohol mixture. The change in refractive index in the effluent liquid was determined interferometrically according to Claesson[3].

The chromatograms of Figs. 1 and 2 show that sharp fronts have been obtained.

When a solution of the 1,2,5- and 1,2,6-isomers was absorbed at the top of the column and a solution of the 1,3,5-isomer was then forced through the column, the first two isomers were displaced[4] by the third and a complete separation was achieved, as can be seen from Fig. 3.

In the first example, the extent of absorption follows the sequence :

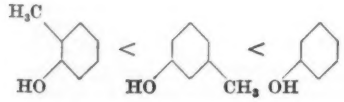


and in the second example :

caproic acid < butyric acid < propionic acid.

It must be emphasized that in the case of xylenols the extent of absorption increases with the separation between the methyl groups and the phenolic group.

The same rule has been found to hold for the absorption of *o*-cresol, *m*-cresol and phenol, where the sequence is :



Therefore, what might be called a 'screening effect' of the methyl groups on the OH group is likely to control the ability to form hydrogen bonds. It is interesting that the same effect seems to control the sequence in the partition coefficients of isomeric phenols between water and *cyclo*hexane[5].

This type of chromatography which has been described is an uncommon example of partition chromatography which might be termed 'sorption chromatography'. The method is very similar to liquid–liquid partition chromatography, the main difference being that one of the two solvents is the amorphous part of a polymer. The large capacity of the absorbent, which may take up to 50 per cent of its own weight of a polar substance, and the fact that it is able to support itself might make sorption chromatography very efficient for preparative purposes and for large-scale separations. Interesting results may be achieved in this way by applying less traditional chromatographic methods, taking advantage of the possibility of using the polymer both as fixed and mobile phase. The polymer could, for example, be used as a mobile phase in the form of long fibres, which, as pointed out by Martin[6], would be the most suitable form for an adsorbent to be used in a continuous separation.

Finally, an attractive feature of sorption chromatography lies in the possibility of choosing a suitable polymer for any given group of compounds to be separated. The sorption capacity of a given polymer could also be enhanced by suitable chemical modifications, or by block or graft copolymerization.

We are indebted to Dr. A. J. P. Martin for a valuable discussion and for reading the manuscript of this communication.

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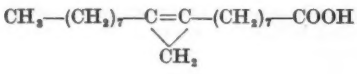
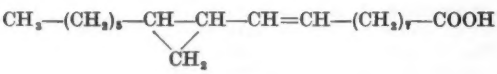
Structure of Sterculic Acid and other Analogous Fatty Acids

For sterculic acid Nunn[1] has suggested structure (I) ; Verma *et al.*[2] have recently proposed structure (II).



(I)



(II)

In the course of an investigation into the composition of kapok seed oil, which is supposed to contain a fatty acid with a similar grouping, evidence has been found in support of structure (I) suggested by Nunn.

(1) Characteristic of the particular grouping in question is an infra-red absorption at 1,009 cm.$^{-1}$ (1,004 cm.$^{-1}$ by Verma); on careful hydrogenation a dihydro-derivative was obtained having an absorption of 1,021 cm.$^{-1}$ (1,015 cm.$^{-1}$ by Nunn). This characteristic frequency near 1,020 cm.$^{-1}$ of the *cyclo*propane ring is an 'in-plane wagging vibration' of the CH_2-group[3]. On conjugation with a C=C bond a slight displacement is to be expected, which actually occurs towards higher frequencies; Slabey[4] has found the following values: 2-*cyclo*propylpropane 1,018 cm.$^{-1}$; 2-*cyclo*propylpropene 1,023 cm.$^{-1}$.

However, the difference between 1,021 cm.$^{-1}$ and the 1,009 cm.$^{-1}$ occurring on the transition of dihydrosterculic acid to sterculic acid is considerably greater, and means a displacement in another direction. This may be due to the increased ring strain which is to be expected in a *cyclo*propene ring, and which has been established by means of electron diffraction measurements[5].

That this frequency is actually lowered by ring strain is also borne out by its displacement in the following series: *Cyclo*hexane 1,028 cm.$^{-1}$, *cyclo*pentane 1,028 cm.$^{-1}$, *cyclo*propane 1,023 cm.$^{-1}$, *cyclo*propene (?) 1,009 cm.$^{-1}$.

(2) *Sterculia fœtida* oil[6], kapok seed oil[7], and cotton seed oil[7] give the Halphen reaction (reddening with a solution of sulphur in carbon disulphide). With the first two oils the reaction is attended with the occurrence of a band at 1,009 cm.$^{-1}$; with cotton seed oil this band could not be detected, but this is probably caused by the sensitivity of the reaction and the extremely small amount of a similar fatty acid in cotton seed oil.

Whenever treatment of the oils caused the band to disappear, the Halphen reaction became negative, so that this reaction is apparently characteristic for the grouping in question.

As *cyclo*propane derivatives or conjugated systems do not give the Halphen reaction, it seems characteristic of the *cyclo*propene grouping rather than of structure II.

(3) The *cyclo*propane group is less reactive than the ethylene bond. A smaller activity is also to be expected from this system in conjugation with a C=C bond (II) than from a system of two conjugated double bonds. Sterculic acid, however, polymerizes very rapidly[1], whereas 9,11-octadecadienoic acid is fairly stable at room temperature.

In a more detailed publication we intend to adduce further arguments. Our work has mainly been concerned with the isolation of an as yet unknown 'kapok fatty acid'. The dihydro-bombacic acid (we suggest the name 'bombacic acid' for the unknown 'kapok fatty acid', derived from the family name Bombacaceae) prepared by us appeared to be a C_{18}-acid, in contrast to dihydro-sterculic acid, the chain-length (C_{19}) of which was verified.

Thanks are due to the management of Unilever N.V., Rotterdam, for permission to publish this communication.

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Paper Electrophoresis of Amino-Acids and Oligopeptides at Very High Potential Gradients

The importance of the amino-acids and oligopeptides and the complexity of their mixtures often encountered stimulate a demand for more powerful analytical tools to complement those already available. Paper electrophoresis does not show satisfactory resolving power, particularly in the separation of the neutral amino-acids, at the low potential gradients (5–10 V./cm.) usually applied. Its value is greatly

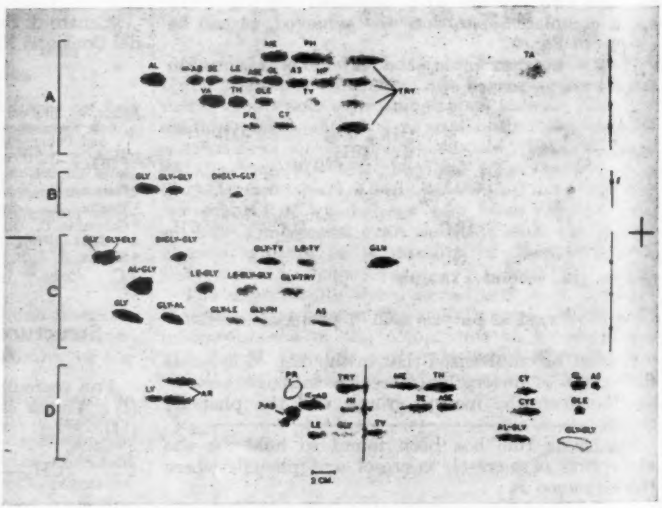

Fig. 1. Electrophoresis of amino-acids and peptides
Amino-Acids: *α-AB* = α-amino-butyric acid, *β-AB* = β-amino-butyric acid, *γ-AB* = γ-amino-butyric acid, *AL* = α-alanine, *AR* = arginine, *AS* = aspartic acid, *ASE* = asparagine, *CY* = cystine, *CYE* = cysteine, *GL* = glutamic acid, *GLE* = glutamine, *GLY* = glycine, *HI* = histidine, *HP* = hydroxy-proline, *I-LE* = isoleucine, *LE* = leucine, *LY* = lysine, *ME* = methionine, *PH* = phenyl-alanine, *PR* = proline, *SE* = serine, *TA* = taurine, *TH* = threonine, *TRY* = tryptophan, *TY* = tyrosine, *VA* = valine.
Peptides: *AL-GLY* = alanyl-glycine, *DIGLY-GLY* = diglycyl-glycine, *GLU* = glutathione (red.), *GLY-AL* = glycyl-alanine, *GLY-GLY* = glycyl-glycine, *GLY-LE* = glycyl-leucine, *GLY-PH* = glycyl-phenylalanine, *GLY-TRY* = glycyl-tryptophan, *GLY-TY* = glycyl-tyrosine, *HI-HI* = histidyl-histidine, *LE-GLY* = leucyl-glycine, *LE-GLY-GLY* = leucyl-glycyl-glycine, *LE-TY* = leucyl-tyrosine.
Conditions: (*A*) 90 V./cm., 6 m.amp./cm., Whatman No. 3 *MM.* 4 in. × 22½ in. strip, 1·5 *M* formic acid + 2 *M* acetic acid (1 : 1) buffer sol., *p*H 2·0, 2–10 μgm. of each compound (according to sensitivity of ninhydrin reaction) applied 3 in. from anode end, 1½ hr. (*B*) 65 V./cm., 9 m.amp./cm., 1·5 *M* formic acid buffer sol., *p*H 1·8, 1½ hr. (*C*) 90 V./cm., 6·5 m.amp./cm., buffer sol., *p*H 2·0 (as above), 5–15 μgm. of each compound applied, 1½ hr. (*D*) 90 V./cm., 8 m.amp./cm., 0·05 *M* sodium borate buffer sol., *p*H 9·2 applied in centre of strip, 1 hr.

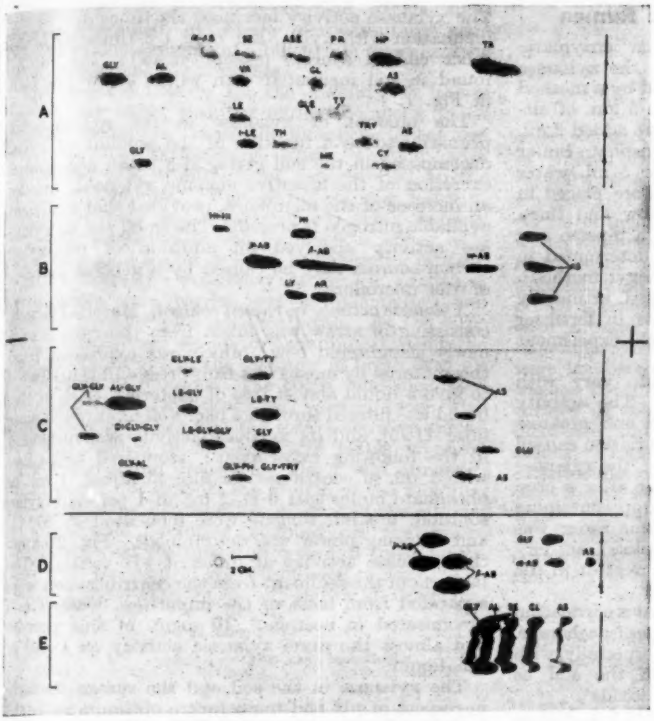

Fig. 2. Electrophoresis of amino-acids and peptides
As in Fig. 1. Conditions: (*A*) 110 V./cm., 2·4 m.amp./cm., Whatman No. 3 *MM* 5 in. × 22½ in. strip, buffer sol., *p*H 2·9 (454 ml. 2 *M* acetic acid, 6 ml. 2 *M* sodium acetate, 540 ml. water), amount of compounds and place applied as in Fig. 1, 1½ hr. (*B*) 90 V./cm., 2·2 m.amp./cm., ½ hr. (*C*) 110 V./cm., 2·3 m.amp./cm., 1 hr. (*D*) 200 V./cm., 7 m.amp./cm., 2 in. × 11 in. strip, 8 min. (*E*) 200 V./cm., 8 m.amp./cm., 15 min.

enhanced, however, by the application of high potential gradients, most likely because the great reduction in time required for the molecules to traverse a given distance minimizes the detrimental effects of diffusion and moisture changes in the paper strip. Technical difficulties arising from increased heat generation can be overcome by modification of the design of basic equipment and by efficient cooling.

Although Durrum[1] applied a field strength of about 25 V./cm. satisfactorily, it was Michl[2] who first used high potential gradients of more than 40 V./cm., but the shortness of the paper strip used limited his results. Kickhöfen and Westphal, and more recently Heilmeyer *et al.*[3], by adopting Michl's design of equipment and applying potential gradients of up to 120 V./cm., achieved very striking separations of mixtures of chemically and electrically closely related amino-acids and peptides.

My high-voltage technique[4] differs basically from that of the former workers[2,3] in that it is a horizontal closed-strip method with applied pressure and efficient water cooling, allowing the application of 0·7 W./cm.² and even more, depending on the temperature of the tap water. The effective length of the strip is 45 cm. A smoothed, full-wave rectified current at up to 6,000 V. is supplied by a power pack, making the application of potential gradients of up to 130 V./cm. possible. In one particular series of experiments 200 V./cm. was applied to a strip of 25 cm. length. A detailed description of the equipment will be published elsewhere[5].

Results obtained using three selected buffer solutions of *p*H values 2·0, 2·9 and 9·2 are illustrated by Figs. 1 and 2. It is thought that the presentation of results in this form is preferable to the tabulation of mobility values or migration-rates, since separations are often dependent not only upon the differences in migration-rates, but also upon the quality of the spot, that is, its shape, size, tendency to streak, etc. This applies to a lesser degree to bands. Fig. 1 shows the electrophoretic behaviour of twenty-three amino-acids and twelve oligopeptides at *p*H 2·0 (*A*–*C*) and *p*H 9·2 (*D*).

At *p*H 2·0 (*A*) the positions of some compounds, both absolute and relative to each other, were found to be in disagreement with those reported previously by Kickhöfen and Westphal[3]; for example, tryptophan, serine, proline and tyrosine. In the case of glycine, glycyl-glycine and diglycyl-glycine (*B* and *C*), the *p*H of the buffer solution appeared to be very critical, as between *p*H 2·9 and 1·8 the migration-rate of glycine increases rapidly with decreasing *p*H. On the whole, migration-rates of amino-acids were faster, so that they could be separated in about one-third of the time reported by Kickhöfen, whereas comparable peptides required about the same time. Separation at *p*H 9·2 offers additional differentiation between methionine and threonine, tyrosine and aspartic acid, cystine and glutamic acid, etc. Fig. 2 shows the electrophoretic behaviour of 24 amino-acids and 13 oligopeptides at *p*H 2·9.

Of particular interest are the separation of the basic amino-acids (*B*) within half an hour and the exploratory separations at 200 V./cm. of some basic, acid and neutral amino-acids within 8–15 min. (*D* and *E*).

Good reproducibility and speed of process have made electrophoretic separations very helpful in my laboratory for testing fractions of eluate from ion-exchange columns during the run. Used as a second dimension for paper chromatograms, electrophoresis has provided additional and often decisive information on the identity of components of mixtures derived from plant products.

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Xylanase in the Soil and the Rumen

In connexion with experiments on enzymatic decomposition of wheat straw xylan[1], the xylanase activity in the soil has been investigated by a method very similar to that of Hofmann[2]. To 5 gm. of air-dry soil in 50-ml. Erlenmeyer flasks were added 2 ml. of toluene, and, after 10 min., 5 ml. phosphate buffer (*p*H 6·5) and 5 ml. xylan solution, or 5 ml. water in the blanks. The stoppered flasks were placed in an incubator at 37° C. and shaken now and then. Samples were taken out by means of a pipette and centrifuged, and reducing power was determined in 1 ml. of the supernatant by the Somogyi method[3]. Soil samples were taken from unfertilized, artificially fertilized and farmyard manured plots in fertilizer experiments at Danish Government field experiment stations.

The xylanase activity was found to vary with the manuring and the kind of crop. The activity was smallest in the unfertilized plots and greatest in the farmyard-manured ones. The variation caused by the crop was, however, much larger; the xylanase activity was three to five times greater after a crop containing xylan (wheat) than after a crop containing no or little xylan (beets); but the same order was observed within each set of samples (plots), activity being smallest in the unfertilized and greatest in the farmyard manured plots.

Recent investigations have shown that a correlation exists between the activity of soil enzymes (saccharase, urease) and fertilization or manuring especially with nitrogen[4,5], and biological activity of the soil as determined by production of carbon dioxide[6].

Portions of 25 gm. of a loam soil (*p*H 6·2, humus 2·2 per cent) from an unfertilized plot with low xylanase activity were incubated in beakers for fifteen days at 25° C., with addition of: (*a*) powdered wheat straw in amounts from 0–2·0 per cent, (*b*) 0·5 per cent xylan, mannan, starch, cellulose, xylose, arabinose or glucose. 10 per cent water and 0·05 per cent ammonium nitrate were added in each case, and evaporated water was restored during incubation.

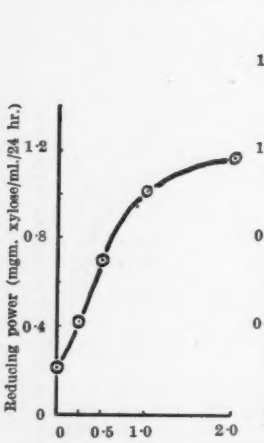

Fig. 1

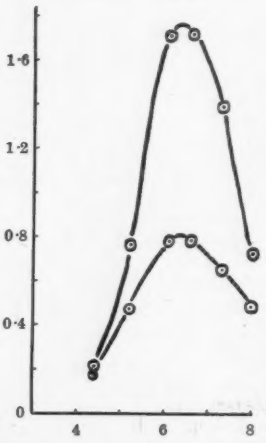

Fig. 2

Fig. 1. Xylanase activity in soil after incubation with increasing amounts of powdered wheat straw

Fig. 2. Xylanase activity in rumen liquid at different *p*H. Upper curve, centrifuged liquid; lower curve, sterile filtrate

The xylanase activity increased six times due to the incubation with xylan, but only 1·3 times with the other carbon sources (except straw); the results found in soil incubated with wheat straw are seen in Fig. 1.

The amount of xylanase in the soil appears primarily to be a function of the amount of xylan decomposed in the soil giving rise to an accelerated excretion of the adaptive enzyme xylanase, besides an increase of the microflora, provided that sufficient available nitrogen is present. The small rise in xylanase activity observed on addition of non-xylan carbon sources may be caused by a general increase of the microflora.

Xylanase activity in rumen content. Material largely consisting of straw was taken from the rumen of a newly slaughtered cow. Juice was expressed from this material by means of a fruit press and centrifuged to give a liquid almost free of bacteria; part of this liquid was filtered through a bacterial filter (Jena glass filter 11*G*5), and its xylanase activity was measured in the following experiment: stoppered test-tubes with 1 ml. of centrifuged or filtered liquid, 1 ml. of phosphate buffer (*p*H 6·2), 2 ml. of 1 per cent xylan solution, 0·5 ml. toluene were incubated at 37° C., and reducing power was determined[3]. Fig. 2 shows the xylanase activity at different *p*H values. The bacteria in the sediment from the centrifugation were separated from most of the impurities, washed and precipitated in acetone. 10 mgm. of this powder had almost the same xylanase activity as 1 ml. of the liquid.

The xylanase in the soil and the rumen conform in respect of *p*H and temperature optimum with the xylanase from pure cultures. The reaction products have been isolated and determined on paper chromatograms, and xylose, xylobiose, xylotriose, etc., have been observed, as in studies with xylanase from pure cultures[1].

A more detailed account will appear later.

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Auxotrophic Mutants of *Pseudomonas aeruginosa*

Auxotrophic mutants of a strain of *Pseudomonas aeruginosa* were isolated by Loutit[1] following X-ray treatment and using a modification of the penicillin-isolation technique devised by Davis[2] and Lederberg and Zinder[3]. An attempt was made to repeat this work using a new strain of *Pseudomonas aeruginosa*; but from a series of ten experiments only one auxotrophic mutant was isolated. A further thirty experiments were carried out on this new strain, using ultra-violet irradiation instead of X-rays and employing the same isolation technique. From these thirty experiments only eleven mutants were isolated,

representing less than 0·2 per cent of the total colonies examined. Six of the eleven mutants were isolated in one experiment; but five of these had the same nutritional requirements.

The possible reasons for the inability to isolate mutants lay either with the mutagenic agent or the selective technique. Since the mutagenic agent was found to be satisfactory when working with *Escherichia coli*, attention was concentrated on the selective technique. One aspect of the selective technique which was considered was the possibility of genetic exchange, which could occur either as a result of sexual fusion or some transforming process.

To examine the possibility of genetic exchange, experiments were carried out by inoculating two mutants together into nutrient broth. At the same time, controls were set up for each mutant using the same inoculum in half the quantity of broth used for the mixture of mutants. The tubes were incubated overnight, the cells centrifuged, washed twice with sterile distilled water and the total cells were spread over the surface of minimal agar plates prepared using the medium devised by Davis and Mingioli[4], which would not support the growth of the mutants. The plates were incubated for 24 hr. and the number of prototrophic colonies counted on the plates inoculated with the mixed growth and those inoculated with the control growth of each mutant. The results of these experiments are shown in Table 1.

Table 1

Cross	Number of prototrophs: Mixture	Total controls
B_5m^- × B_9m^-	9 (2 ml.)	0 (1 + 1 ml.)
B_7m^- × B_9m^-	92 (5 ml.)	8 (2·5 + 2·5 ml.)
B_7m^- × B_9m^-	3,628 (20 ml.)	447 (10 + 10 ml.)
B_7m^- × $B_{11}h^-$	609 (2 ml.)	183 (1 + 1 ml.)
B_7m^- × $B_{11}h^-$	4,593 (5 ml.)	1,581 (2·5 + 2·5 ml.)
$B_{17}ad^-$ × $B_{21}l^-$*	51 (2 ml.)	2 (1 + 1 ml.)

m^- = methionineless; h^- = histidineless; ad^- = adenineless; l^- = leucineless.

* This result was obtained using two mutants isolated in subsequent experiments.

Since the number of prototrophic colonies was greater on the plates inoculated with the mixed mutants than those inoculated separately with individual mutants, there was some justification in assuming that a process of genetic transfer could occur.

In the isolation method, genetic transfer could occur at the stage of incubation of the cells in broth immediately after irradiation and thus prevent the isolation of the mutants. To overcome this difficulty, the technique of Adelberg and Meyers[6] was adapted. In this technique the cells were incorporated in minimal agar after irradiation and incubated for 6 hr., thus isolating each cell from its neighbour and preventing either fusion or transformation. The only modifications necessary to the technique were increases in the amount of penicillin and penicillinase. The quality of the penicillinase was important; a purified product was necessary. Most commercial preparations were unsatisfactory as they were simply culture filtrates containing growth factors. The material used for the present work was prepared in this laboratory according to the method of Morgan and Campbell[6].

Using the Adelberg and Meyers technique, relatively high numbers of mutants were isolated in three separate experiments as shown in Table 2.

These results showed that the penicillin-isolation technique was satisfactory for isolation of mutants,

Table 2

	Number of mutants	Total number of colonies examined after penicillin treatment
Experiment I	10	70
" II	25	170
" III	60	170

provided the organisms were not grown in broth but in minimal agar for the period of incubation necessary for full expression of the mutants. It is suggested that a process of genetic exchange occurred during that period of incubation in broth, masking any mutants which were present. To confirm that genetic transfer could occur under the conditions used in the early isolation work, two mutants, $B_{17}{}^{ad^-}$ and $B_{21}{}^{l^-}$, were grown separately and irradiated. Half the cells of each mutant were then mixed in broth and the remainder inoculated separately in broth. The tubes were incubated for 6 hr., the cells were centrifuged, washed twice in distilled water and spread over the surface of minimal agar plates. The plates were incubated and scored for the appearance of prototrophs. From the mixture of irradiated cells in two experiments, eight and seven prototrophs respectively were found, while there was none in any of the controls. This amount of genetic exchange considered in conjunction with the fact that all mutants do not survive the penicillin treatment would probably be sufficient to prevent the isolation of mutants.

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Mode of Cleavage of the Eggs of *Hydroides norvegica* in the Mediterranean

In a recent paper[1], it was pointed out that the eggs of the marine polychaete *Hydroides norvegica* may have different cleavage patterns in the North Sea and in the Mediterranean. Whereas at the Kristineberg Zoological Station (near Fiskebäckskil), on the west coast of Sweden, Wolsky found the early cleavage to be spiral and equal, an earlier observer, Soulier[2], working at Cette (Séte), on the Mediterranean coast of France, found it orthoradial and unequal. It was suggested that this difference may be a sign of differentiation of two distinct physiological races within the species, and it was thought desirable to check the correctness of this suggestion. A short visit to Naples in April 1954 and the hospitality of the Stazione Zoologica, for which I am greatly indebted, made it possible to carry out such a check on Mediterranean material.

As regards the relative position of the cleavage planes, Soulier's finding that the cleavage is orthoradial up to the 16-cell stage could not be confirmed. Spirality can be detected in the 4-cell stage already, and an analysis of camera lucida drawings almost invariably reveals polar furrows (Fig. 1*a*). Consequently, the sudden change of the configuration of the blastomeres from the orthoradial to the spiral type in the 16-cell stage, as described by Soulier,

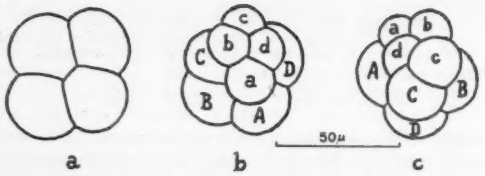

Fig. 1. Cleavage stages of *Hydroides norvegica* in the Mediterranean (Gulf of Naples). (*a*): 4-cell stage showing spirality and polar furrow; (*b*) and (*c*): 8-cell stages showing extreme inequality of blastomeres and irregularity of blastomere arrangement. (In both cases it is the blastomere labelled *C* which seems to have drifted 'out of place')

cannot take place. However there is evidence that blastomeres frequently change their original position relative to each other, and sometimes their configuration is quite irregular (cf. Figs. 1*b* and *c*).

Concerning the inequality of the cleavage, the difference between North Sea and Mediterranean eggs is also less striking than assumed on the basis of Soulier's categorical statement (ref. 2, p. 1662). The 1/8-blastomeres of *Hydroides* eggs are slightly unequal even in the North Sea (ref. 1, Table 1), and therefore the difference between the North Sea and Mediterranean material is rather one of degree than of category.

Circumferences of blastomeres were measured on a number of camera lucida drawings of eggs in the 8-cell stage, and the results are given in Table 1. (The results are in the same arbitrary units as used for the North Sea material, one unit being approximately 9μ.) A comparison of these data with those for North Sea eggs (ref. 1, Table 1) shows that the inequality of the cleavage is somewhat more pronounced in the Mediterranean than in the North Sea material. In the North Sea the size difference of sister blastomeres ranges from 0 to 20 per cent and is on the average 6·5 per cent. (In my earlier paper[1], this figure is given erroneously as 3·5 on pp. 343 and 347, but the correct value can be obtained from the data of Table 1 on p. 343.) In the Mediterranean, on the other hand, the size differences vary between 0 and 39 per cent, and the average is 16·8 per cent, that is, 2½ times the value for the North Sea eggs. This is a definite indication that the cleavage is somewhat more unequal in the Mediterranean than in the North Sea material. However, it is rather difficult to treat these data statistically and to express exactly the degree of the inequality of cleavage or the significance of its difference in two or more populations. For this reason the difference between the Mediterranean and North Sea material as regards inequality of the cleavage cannot be considered as statistically established. Although it very probably exists, further results must be awaited before statistical evidence can be furnished.

Table 1

Egg \ Blastomere	A	a	B	b	C	c	D	d
22/120	6·5	5·8	5·8	5·2	7·2	5·2	5·8	5·8
22/330	7·8	7·2	7·8	5·8	6·5	6·5	7·2	7·2
22/358	7·8	7·2	7·2	5·8	7·2	6·5	7·8	6·5
22/415	7·8	7·2	9·0	6·5	8·5	6·5	8·5	7·2
22/425	8·5	6·5	8·5	5·8	7·8	5·8	8·5	5·2
24/300	8·5	6·5	7·2	5·8	7·2	7·2	5·8	6·5
24/505	7·2	5·8	7·2	5·8	7·8	6·5	6·5	5·8
24/518	7·2	5·2	7·8	6·5	7·2	6·5	7·2	5·2
24/525	7·8	5·8	7·8	5·8	7·2	5·8	7·2	7·2
26/200	7·8	6·5	7·8	6·5	7·8	6·5	8·5	6·5
26/210	7·2	5·8	7·2	5·2	7·8	6·5	7·2	6·5
26/220	7·8	6·5	7·8	6·5	7·8	6·5	7·8	5·8

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Demonstration *in vivo* and *in vitro* of Peristaltic Contractions in the Portal Vein of Adult Mammals (Rodents)

In previous investigations evidence has been produced of a spontaneous peristaltic activity in veins of the hepatic portal system of chick embryos and newly hatched chickens[1] and of adult goldfinches and in the portal vein of adult mice[2], cultivated *in vitro*. In the latter the contractions are very powerful and of very high frequency (up to 70 per min.), and activity continues for a long time (up to more than two weeks without washing or renewal of the nutritive medium).

In continuation of these investigations a similar peristaltic activity has been observed in the portal vein of albino rats and guinea pigs, explanted *in vitro*: in the former a frequency of contraction up to 35 per min., in the latter up to 20 per min., have been recorded.

With the aim of ascertaining whether this rhythmical contractile activity occurs also in the vessel *in situ* in the living animal, I have made some observations on albino mice and rats.

For this investigation the following technique has been employed. The animal is anæsthetized by ether and laparatomized; the liver is lifted up and the duodenum displaced to the left, so that the portal vein is exposed. The field is continuously irrigated with a physiological salt solution at 38°–39° C. and a coverslip is placed over it, care being taken not to bear any pressure upon the vessel. It is thus easy to observe rhythmical contractions of the portal vein, with a propagation of the contractile wave in the direction of the liver and a frequency up to 30 per min. in the mouse, up to 14 per min. in the rat. In the state of relaxation of the wall, it is possible to recognize on its surface one or more slight indentations, which correspond to the spiral fold projecting into the lumen, which has been described in the portal vein of these and other mammals[3,4].

If the animal is killed, for example, by administration of a large dose of ether, the peristaltic activity persists for some hours with remarkable intensity; indeed, the activity can be studied more easily, as the respiratory excursions of the diaphragm, which cause rhythmical movements of the liver and of the vessels attached to it, no longer interfere with observations. After the death of the animal a frequency of the contraction up to 52 per min. in the mouse and up to 22 per min. in the rat has been recorded.

Half an hour to one hour after death it becomes possible, owing to the sedimentation of the blood cells and the transparency of the plasma and of the venous wall, to perceive within the lumen, in the phase of relaxation of the vessel, the spiral fold already mentioned; during the contraction of the vein the spiral fold seems to be incorporated in the wall, so that it becomes for the most part invisible.

The function of this fold, as well as that of similar spiral structures projecting into the lumen described

within the portal vein of other mammalian species[1–6], is probably, according to Barnett, to mix the various streams of blood that enter the portal vein, so that the different lobes of the liver can all receive the same kind of blood. This is especially important in animals possessing multilobed livers, and as a matter of fact in these animals spiral structures are particularly well marked.

As regards the rhythmical peristalsis of the portal vein, it seems safe to assume that it plays a part in the propulsion of blood towards the hepatic capillary bed.

Further researches in this direction are in progress.

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Rust Resistance in Sunflowers (*Helianthus annuus* L.)

Rust (*Puccinia helianthi* Schw.) is a major hazard to sunflower production in a number of countries. The area devoted to sunflowers for edible oil in Canada, all in southern Manitoba, was reduced from 60,000 acres in 1949 to 3,500 in 1952, largely because of losses from rust. The Argentine crop was severely damaged by rust in 1952–53. In Peru, where sunflowers were grown for fodder, rust has practically eliminated the crop. The search for rust resistance is therefore a prime objective in sunflower breeding. The present communication is a preliminary report on resistance which has been discovered in the Canadian sunflower investigations.

Three sources of rust resistance have been recognized to date. The first resistant plant was found in 1949 in an F_2 population of the natural cross, Sunrise × Texas Wild Annual, in a field nursery. Seedlings from selfed seed of this plant proved resistant to rust when inoculated in the greenhouse. Field-grown plants of the progeny were used as male parents in crosses with rust-susceptible inbred lines of commercial agronomic type. The F_1 populations contained plants which were only lightly infected in the field in 1951, the year of the severest rust outbreak ever recorded in Canada. One hundred and thirty-three lines of later generations, selected on the basis of agronomic type from 1,500 lines, averaged only 9·6 per cent rust infection in the field compared to an average of 26·9 per cent in susceptible check material. From the 133 lines, 320 plants with 5 per cent or less rust were selfed. Seedlings derived from them were inoculated in the greenhouse with three different single-pustule isolates of rust. On the basis of reaction type, 70 per cent of the progenies showed resistance. Twenty-six progenies were grown in isolation and allowed to interpollinate to produce the recently licensed rust-resistant variety Beacon. Several inbred lines from the same source have uniformly low rust infections, in some cases less than 1 per cent when susceptible check plants have 10–90 per cent.

The second source of rust resistance was one large plant discovered in 1951 in the F_3 progeny of the natural cross California Oilseed × Texas Wild Annual. When eleven seedlings from open-pollinated seed of this plant were inoculated with the three isolates of rust mentioned above, six proved resistant and five susceptible. Seed of fifty-eight selfed plants of the same progeny yielded two outstanding lines in the field in 1952. Of thirty plants in the two lines, eleven were free of rust, fifteen had only one or very few pustules, and four had one or a few pustules on most leaves. Several other lines also contained plants which were free of rust. Nearby check plants had 20–80 per cent infection.

Selfed progenies of twenty-one plants from the two lines mentioned above were inoculated in two tests with three isolates of rust in the greenhouse in 1952–53. Ten of the twenty-one progenies were resistant in all inoculations; the others segregated. Derivatives of the ten progenies continue to show high field-resistance in later generations. Sunflowers with the same parentage have also proved resistant to rust in the field in Peru and Argentina.

The third source of resistance was one plant with low rust infection in a field plot in 1952 from seed of open-pollinated plants of the variety Hopi. The second selfed generation from this plant, tested in the greenhouse with a field collection of rust, contained twenty-five resistant and twenty-four susceptible seedlings. Eleven third-generation selfed progenies, each with eight to fifteen plants, were grown in the field. One progeny had 1 per cent or less rust on all plants; two progenies had 2 per cent or less; and seven progenies had 5 per cent or less. Adjacent susceptible plants had up to 90 per cent infection.

The first two of the three sources of resistance are assumed to have been derived from wild *Helianthus annuus* L., on the basis of plant type in the segregating populations, and because of the absence of other wild annual species of *Helianthus* in the region of Renner, Texas, where the seed originated. As the rust-resistant Hopi plant came from open-pollinated seed produced at Renner, it may also have derived its resistance from the wild *H. annuus*. Although wild forms of *H. annuus* occur over a large part of the North American plains, including the sunflower-growing region of Canada, no rust resistance has been recognized from any location other than Renner.

Studies are now in progress to determine if the same genes are involved in all three sources of rust resistance, and to determine the inheritance of resistance from each of the three sources when crossed with susceptible plants.

Fuller reports of these and related investigations will appear elsewhere. We acknowledge the contributions made to this work by Dr. W. A. Russell during 1949–52, while he was at the Experimental Station at Morden, and by Mr. A. M. Brown, Plant Pathology Laboratory, Winnipeg, during 1949–50.

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Termination Reaction in Vinyl Polymerization: Preparation of Block Copolymers

The nature of the termination reaction in vinyl polymerization, that is, the question of disproportionation or combination of polymeric free radicals, has been the subject of controversy. A number of methods have been used for distinguishing between the various possibilities[1–4]; these depend on relations between degrees of polymerization measured by osmotic pressure and end-group analysis, or on relations between rate and molecular weight data. In all these cases the extremes of 100 per cent disproportionation of radicals and 100 per cent combination give rise only to a difference of a factor of two in the appropriate quantity which is compared with experiment. These methods have been applied to comparatively few monomers, and results obtained by different groups of workers have not always been in agreement[3,4]. We therefore thought it worth while to attempt to devise an independent method of general application which would be more sensitive in its distinction between combination and disproportionation. We now wish to describe briefly the method which has been developed and its application to four vinyl monomers.

The method depends on the use of an initiator containing functional groups so arranged that every free radical produced contains one such group. If the conditions of polymerization are such that chain transfer to monomer, solvent and polymer is negligible, each growing radical will carry one functional group at its inactive end; hence the final polymer molecules will have a functional group either at one or both ends, depending on whether termination occurs by disproportionation or combination of radicals. (The argument so far is identical with that employed in methods involving the use of labelled initiators.) The two types of polymer may readily be distinguished by reaction with an equivalent of a bifunctional reagent capable of linking the polymer molecules by their terminal functional groups. If termination occurs exclusively by disproportionation, the polymer molecules can only be joined in pairs, so that the number average degree of polymerization can increase at most to twice its initial value (neglecting the molecular weight of the ligand). On the other hand, if termination occurs exclusively by combination, theoretically *all* the polymer molecules could be joined together, and under suitable conditions the degree of polymerization would be expected to increase to much more than twice the initial value. Both types of behaviour have been observed.

One initiator employed was γγ′-azo-(γ-cyano-*n*-valeric acid), which decomposes thermally to yield radicals of structure, $HOOC(CH_2)_2\dot{C}(CH_3)CN$. After polymerization and purification of the polymer by repeated precipitation, the carboxyl content was estimated by titration. A sample of the polymer was converted into the corresponding acyl chloride by treatment with thionyl chloride, the excess of which was then removed in vacuum. Coupling was carried out in methyl ethyl ketone solution at 90° C., using 1 : 6 hexane diol or 1 : 10 decane diol. After precipitating and drying the polymer, its intrinsic viscosity was measured and compared with the original value. Some results are shown in Table 1. In each case we have taken $1/\alpha = 1{\cdot}40$, α being the Houwink constant.

The results show that chain-termination occurs substantially by combination in the case of styrene, and by disproportionation with the other monomers. Our conclusions agree with those of Mayo, Gregg and Matheson[1], Baysal and Tobolsky[2] and Bevington, Melville and Taylor[4] for styrene, and with Bevington *et al.*[4] for methyl methacrylate.

Table 1

Monomer	Conditions of polymerization	Intrinsic viscosity (decilitres per gm.) Initial $[\eta]_i$	Final $[\eta]_f$	$\left(\frac{[\eta]_f}{[\eta]_i}\right)^{1/\alpha}$
Styrene	100°, in *o*-dichlorbenzene	0·143	0·818	11·5
	,,	0·143	0·797	11·1
Methyl methacrylate	90°, in benzene	0·145	0·201	1·59
	,,	1·145	0·210	1·69
Vinyl acetate	,,	0·169	0·254	1·76
	,,	0·169	0·268	1·92
Methyl acrylate	,,	0·133	0·220	2·02
	,,	0·133	0·227	2·11

The use of initiators of the type described, together with suitable coupling reactions, obviously enables a large range of block copolymers to be prepared in a simple manner. For example, a block copolymer of styrene and methyl methacrylate in which the molecules contain one block of about a hundred units of styrene between two blocks of methyl methacrylate each of approximately 120 units has been prepared in the pure state, free from the parent polymers. These preparations may be scaled up without difficulty.

This work is being extended to other monomers and to different conditions of polymerization, including the use of other initiators. We hope to publish a more quantitative treatment elsewhere.

We wish to thank Dr. W. A. Waters, of the Dyson Perrins Laboratory, Oxford, for providing us with practical details of the synthesis of γγ′-azo-(γ-cyano-*n*-valeric acid).

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Density of Amorphous Polyethylene Terephthalate

Polyethylene terephthalate can be melt-spun and afterwards hot-drawn to form continuous filament yarn[1] marketed under the trade name of 'Terylene'. In the quenched or spun form, it possesses a very low degree of molecular orientation, and the X-ray diagram shows a characteristic amorphous halo with no evidence of crystalline reflexions. The density of this amorphous form is 1·335 gm./c.c., whereas the calculated crystallite unit-cell density is 1·455 gm./c.c.[2]. With the onset of crystallinity, indicated by an increase in density, the growth of crystallite reflexions in the X-ray diagram, and an increase in the brittleness of the sample, the amorphous halo in the X-ray diagram disappears and hence no X-ray estimate of the degree of crystallinity is possible. It can, however, be estimated from the ratio of the infra-red absorptions in the 898 cm.$^{-1}$ and the 875 cm.$^{-1}$ bands[3], and from the density.

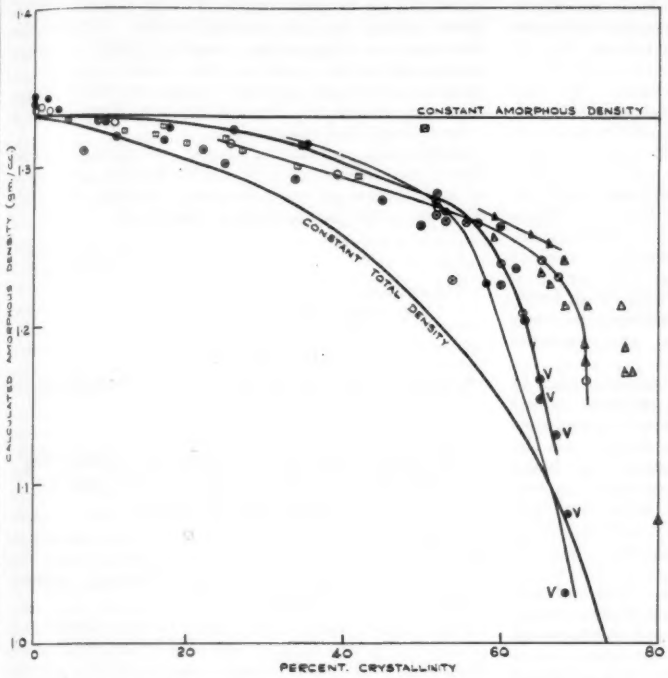

Fig. 1. Calculated amorphous density (gm./c.c.) vs. percentage crystallinity

△, Production 'Terylene' polyester yarns; ▲, Production 'Terylene' polyester yarns (heat-set); ●, yarns spun at low speed; ○, yarns spun at high speed; ⊙, ⊗, ⊡, other experimental yarns; ⊠, unoriented crystalline polymer; *V* denotes presence of internal needle-shaped voids

It has been found that these two measures disagree, the density estimates being considerably lower than the infra-red estimates. Previous work on polyethylene[2] has shown a similar situation in which the crystallinity estimate obtained from the density of the sample is less than that obtained from X-ray data. With increasing hot-stretching of polyethylene terephthalate, the density rises to a flat maximum or even actually decreases, whereas the birefringence, the initial tensile modulus and the infra-red absorption ratio all continue to rise. Furthermore, at high stretch ratios, microscopic voids sometimes appear. These observations thus suggest that the density estimate of crystallinity is suspect, while the infra-red estimate agrees with the other data, increasing uniformly with increasing stretching and heat treatment. Whereas infra-red estimates of up to 80 per cent crystallinity have been obtained, the highest density estimate obtained from a large number of measurements of highly crystalline material is 55 per cent.

Table 1

Polyethylene terephthalate filaments	Density of sample	Crystallinity	
		Density estimate (per cent)	Infra-red estimate (per cent)
Non-crystalline, non-oriented	1·335	0	2
Partly crystalline, non-oriented	1·385	42	48
Highly crystalline, highly oriented	1·390	46	65
	1·389	45	76
	1·381	38	80

Assuming the validity of the infra-red estimate, and knowing the density of the sample and the calculated crystallite density, the corresponding densities of the amorphous region have been calculated for drawn yarns produced under a wide range of conditions and are given in Fig. 1. This shows that the amorphous density decreases with even a small amount of crystallinity, and falls very rapidly at high crystallinities: an increase in the spinning speed, and also a heat treatment after drawing, delay the reduction in density. At the lowest amorphous densities, needle-shaped voids appear at the centre of the filament without any discontinuity in the curves, suggesting that similar voids of submicroscopic size may exist at higher amorphous densities.

It is thus concluded that the amorphous region gradually changes character as crystallization proceeds, and the data suggest the gradual appearance of a fibrillar structure in general qualitative agreement with electron microscope and low-angle X-ray results[4].

The effect of random crystal growth on the amorphous regions would be expected to be less than that due to crystallization which accompanies drawing, on account of the absence of external stress, and Table 1 shows that the density estimate for the former is in better agreement with the infra-red crystallinity estimate.

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Acid Character of Some Phenolic Resins in Relation to their Structure

Aqueous suspensions of finely ground phenol formaldehyde, resorcinol formaldehyde and phloroglucinol formaldehyde resins gave potentiometric titration curves each of which showed an inflexion at a *p*H between 11·0 and 12·0. The amounts of phenolic hydrogen in the three resins indicated by these inflexions were in approximate agreement with the values, 893, 1,563 and 2,083 milliequivalents per 100 gm. calculated from the formulæ, $C_6H_3(OH)(CH_2)_{1\cdot5}$, $C_6H(OH)_3(CH_2)_{1\cdot5}$, and $C_6(OH)_3(CH_2)_{1\cdot5}$, of the repeat units contained in the three resins respectively.

Titration with a dilute base, for example, dilute potassium hydroxide, revealed additional inflexions at lower *p*H values, as can be seen from Fig. 1. Phenol formaldehyde showed an inflexion at *p*H 10·3. The acidity calculated at this inflexion was only about 57·0 m.equiv. per 100 gm. Resorcinol formaldehyde gave two inflexions corresponding to acidities of about 58·0 and 115·0 m.equiv. per 100 gm. Three inflexions were found in the case of phloroglucinol formaldehyde, indicating acidities equal to 55·0, 110·0 and 162·0 m.equiv. per 100 gm. These values were found to be independent of the particle-sizes of the resins and they were obtained, subject to variations of less than ± 2·0 per cent, as often as the resins were prepared with an acid or an alkali as the catalyst, and with any molecular ratio between 1·5 and 3·0 of formaldehyde to the phenolic compound.

The cataphoretic velocity (in cm./sec./volt/cm.) of the resin particles, when plotted against added potassium hydroxide, showed a maximum corresponding to each inflexion (see Fig. 1), the second and the third inflexion of phloroglucinol formaldehyde being covered by a flat maximum. The potassium ion activity of the suspensions measured with the help of clay-membrane electrodes[1] also showed sharp changes corresponding with the inflexions in the *p*H curve.

These inflexions are therefore real. They indicate the neutralization of hydroxyl groups which, apparently, have a stronger acid character than the majority of the hydroxyl groups present in the resin. It is possible that some benzene nuclei are not attacked at all three points by the formaldehyde, and if one assumes that the 'strong' hydroxyl groups are attached to such nuclei, one readily sees why, as noted above, the number of additional inflexions is the same as that of hydroxyl groups present per benzene nucleus. The amount of acid neutralized at the last additional inflexion bears to the total quantity of phenolic hydrogen a ratio which varies from 1:13 to 1:15 in the three resins, and this indicates, in the light of the above assumption, that one in about fifteen benzene nuclei is not attacked at all three points by the formaldehyde. This slight deficiency in cross-linking does not make an appreciable difference between the total quantity of phenolic hydrogen actually found on titration and that calculated on the assumption that complete cross-linking had taken place.

Additional inflexions similar to those reported above have also been found with several other types of solid condensation polymers. Details and fuller discussion will be published elsewhere.

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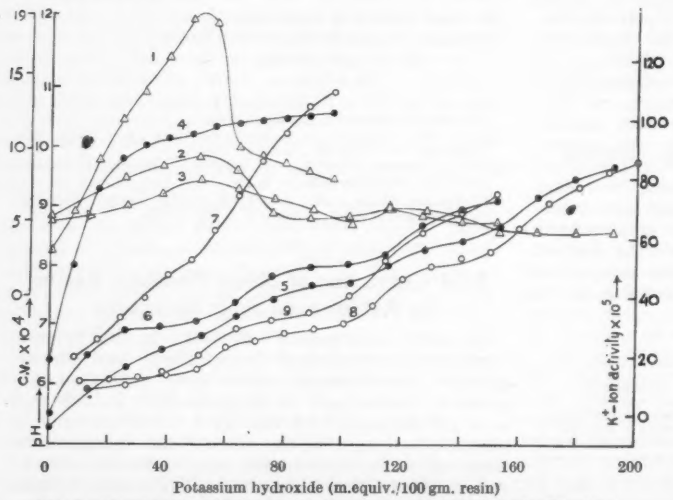

Fig. 1. Cataphoretic velocities (C.V.) for: (1) phenol formaldehyde, (2) phloroglucinol formaldehyde, (3) resorcinol formaldehyde. *p*H: (4) phenol formaldehyde, (5) phloroglucinol formaldehyde, (6) resorcinol formaldehyde. Potassium ion activity: (7) phenol formaldehyde, (8) phloroglucinol formaldehyde, (9) resorcinol formaldehyde

A New Class of Compounds containing the Pentacyanoferrate Group and an Unpaired Electron

Recent work in this Laboratory has established the existence of a class of compounds containing anions of the general formula $[Fe^{II}(CN)_5R_1\dot{N}R]^{3-}$. Here R is an aromatic nucleus which may carry certain substituents and R_1 may be a hydrogen atom or an alkyl group such as a methyl or an ethyl radical. The dot over the nitrogen atom in the formula represents an odd, unpaired electron which, for convenience, is shown associated with a nitrogen atom.

The sodium salts of many of these anions are very soluble in water and give rise to intensely coloured solutions. The maximum extinction coefficients are often comparable with those of dyestuffs. Thus the logarithm to the base 10 of the maximum extinction coefficient in the visible region of the salt $Na_3[Fe(CN)_5H\dot{N}C_6H_4OH]$ prepared from *p*-aminophenol is 4·29, which may be compared with values of 4·5 and 5·0 for malachite green and crystal violet respectively. Several of these compounds (for example, that derived from *p*-aminophenol) are relatively stable and have half-lives of many days in aqueous solution in the presence of air.

The solubilities of the salts of these anions are generally similar to those of the corresponding ferrocyanides; but the groups R and R_1 have some effect on the solubilities. As several of the heavy-metal salts are insoluble in dilute aqueous acetic acid, and as many of these salts are intensely coloured solids, it is probable that solutions of the sodium salts of these complexes will find application as colour reagents for paper chromatography.

These complexes can be made conveniently by allowing the appropriate aromatic amine to react with a faintly alkaline solution of disodium pentacyanoammino-ferrate, that is, with the salt

$Na_3[Fe(CN)_5NH_3]$. For example, *p*-aminophenol reacts with this salt to give the anion $[Fe^{II}(CN)_5HNC_6H_4OH]^{3-}$; but many amines give a more complicated reaction. Thus aniline yields the anion $[Fe^{II}(CN)_5HNC_6H_4NHC_6H_5]^{3-}$, identical with that obtained by the reaction of *p*-aminodiphenylamine with disodium pentacyanoamminoferrate.

Although the iron in these compounds is in the divalent state, yet strong reducing agents (for example, sodium hydrosulphite) destroy the complexes and release the corresponding amine, RR_1NH. This reaction provides a method for the identification of the organic radical in a complex. For example, reduction of the complex prepared from aniline yields *p*-aminodiphenylamine and not aniline.

Unique syntheses may be carried out with the aid of these compounds. For example, *p*-aminodiphenylamine can be prepared directly from aniline, and 2:7-dimethylphenazine (Chemical Society Numbering System) can be made in 40 per cent yield from *p*-toluidine in a single step.

Full details of the preparation and behaviour of these substances, together with evidence of their structure, will be published elsewhere. The work described has been carried out as part of the research programme of the Chemistry Research Board, and this communication is published by permission of the Director, Chemical Research Laboratory

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A New Model Material for Photoelasticity

Gelatin, and a number of imported plastics like 'Catalin 800', '*BT*-61-893', '*CR*-39', 'Marco Resin', etc., are commonly used as model materials. Gelatin is optically more sensitive than all other materials, but has some disadvantages. The stress-optical sensitivity of gelatin[1] varies considerably with the gelatin concentration, glycerine content and temperature; the recommended working range of temperature is 14°–19° C.[2]. In the tropics, the gelatin mix is very weak elastically at room temperature, whereas agar has proved to be more stable.

I have used agar as the model material for photoelastic experiments. This material is cheap, easily available, and very widely used in preparing solid media for bacteriological work; and the models can easily be prepared from it. The stress-optic sensitivity of this material has been calculated from the fringe system obtained with a model of a circular disk in diametral compression, and is found to be better than other plastic substances and as good as gelatin itself.

The fringe constant of the material is found to be as low as 0·08 lb./sq. in./fringe/in. thickness (approximately) for 2–3 per cent agar concentration at 29° C. (using an analyser as the compensator). For 15 per cent gelatin models this value is as high as 0·14 [2]. Though low, the Young's modulus of about 14 lb./sq. in. for 5 per cent agar (obtained by loading a free sample without any side support) compares favourably with the figure 6 lb./sq. in. for 13 per cent gelatin.

An attempt to increase the Young's modulus and the stress-optic sensitivity of the material in combination with other ingredients is being made and the results will be published elsewhere.

I am much obliged to Messrs. T. Ramasarma and G. J. Mohanrao, research students of the Biochemistry Department of this Institute, for discussions and suggestions in the preparation of the model material.

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Spot Chromatography of Hydraulic Mineral Oils using Fuller's Earth

The recent communication by L. H. Bryant[1] on an adsorbent-coated glass technique for circular chromatography of terpenes, etc., was read with interest. A rather similar method was developed in this laboratory in 1948, and various adsorbents were tried; pulverized silica gel appeared to cause some alteration (darkening) in certain of the mineral hydraulic oils tested, so its use was discontinued and ordinary fuller's earth (B.P. grade) used instead. This material (prepared as a trichlorethylene slurry poured on the glass to form a pool and then rapidly poured off to leave a thin film, which is allowed to dry in air) has proved consistently satisfactory. Spot tests made with it provide a convenient means of checking the consistency of different batches of mineral oils by examining the fluorescence of the rings containing the various oil constituents, using ultra-violet light from a mercury in quartz lamp fitted with a Wood's glass filter.

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A Simple Version of Bragg's X-ray Microscope

The method described by Bragg[1] for the artificial production of the image of a crystal structure from its X-ray diffraction pattern is of fundamental importance in the subject of X-ray optics. The experiment, however, requires the use of two accurate lenses which may not be available in most laboratories, and it is the purpose of the present brief communication to show how simpler apparatus can be made to serve the same purpose.

The simplification consists merely in making a small diffracting mask. This may be accomplished in a number of ways[2], but we have found that simple photographic reduction of a drawing is sufficient; over a distance of about 2 mm., a photographic plate is often sufficiently uniform for the optical thickness to be reasonably constant. Moreover, with a small diffracting mask the angles of diffraction are large enough for a lens of long focal length to be unnecessary for viewing the diffraction pattern.

The experiment has been carried out as follows. A drawing (Fig. 1) was made of the *hol* weighted reciprocal-lattice section of nickel-phthalocyanine.

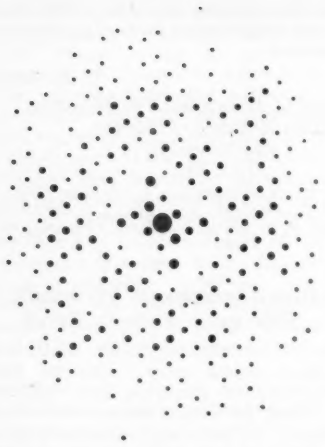

Fig. 1. Weighted reciprocal-lattice section of 'rhodium' phthalocyanine

This crystal nearly satisfies the condition that all the structure factors should be positive, but a few of appreciable magnitude are negative[3]; these were removed by the general addition of a positive scattering factor, so that the results corresponded to a central atom of atomic number 45 (rhodium) instead of 28. The spots in Fig. 1 were given areas roughly proportional to the structure factors. At first sight it may seem that the areas should be proportional to the intensities of the corresponding X-ray reflexions, but this would be so only if the dimensions of the diffraction pattern of a hole were independent of the size of the hole; it can easily be shown that the amplitude at the centre of the diffraction pattern of a circular hole is proportional to the area of the hole.

The drawing was photographed down directly to about 2 mm. diameter on a maximum-resolution plate. An ordinary telescope was then focused on a hole of 5 mm. diameter, about 10 metres distant, illuminated by filtered light from a compact-source mercury-vapour lamp. When the photograph of the reciprocal-lattice section was placed in front of the objective of the telescope, an image of the phthalocyanine molecule could be clearly seen around the central maximum. An improved image (Fig. 2*a*) was obtained by covering the diffracting object with a thin film of cedar-wood oil held in place by a microscope coverslip. Comparison with the calculated Fourier synthesis[3] (Fig. 2*b*) shows that the image is a reasonable representation of the molecule.

Although the demonstration is valuable chiefly as a teaching device for those departments that stress the relationship between physical optics and X-ray diffraction, it is hoped also to explore its usefulness in connexion with the Fourier and Patterson methods for general crystal-structure work.

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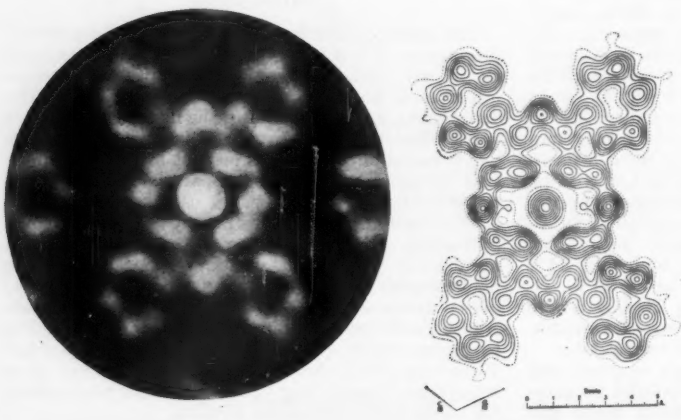
Evaporation of Water from Soil under Field Conditions

Canavan[1] has shown that, under field conditions at Wellesbourne, very small deficits of soil moisture may adversely affect the germination of many kinds of vegetable seeds and the subsequent establishment of the crop. Further investigations have shown that the top inch of a seedbed on light sandy loam contains approximately 0·30 in. of water, not all of which is available for germination.

On the basis of laboratory experiments, Penman[2] concludes that, under summer conditions, evaporation of water from a bare soil takes place at the same rate as evaporation from a free water-surface until a certain critical deficit is reached, approximately 0·35 in. Work during the summer of 1954 at Wellesbourne has shown that several factors may change the relationship between rate of evaporation from bare soil and from a water-surface.

A number of undisturbed cores of soil were taken from a seedbed which was at field capacity and were enclosed in watertight containers. They were then replaced in the seedbed. Similar containers were filled with water and were placed in the seedbed adjacent to the soil cores. All the surfaces were protected from rainfall by a movable glass shelter. The rates of evaporation from the soil and from the water surfaces were compared by daily weighing of the respective containers.

When the total evaporation from the soil surfaces was plotted against total evaporation from free water-surfaces, the curve showed two distinct stages. In the first stage, the loss was equal to the water-loss; but in the second stage the soil-loss became



(*a*) (*b*)

Fig. 2. (*a*) Diffraction pattern of Fig. 1. (*b*) Fourier synthesis of nickel phthalocyanine for comparison with (*a*)

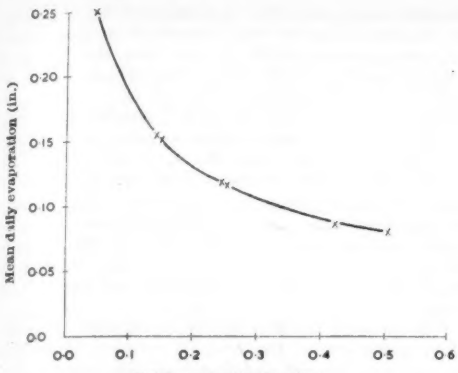


Fig. 1. Relationship between intensity of evaporating conditions and water loss from soil during the period when loss from soil surface equals loss from water surface

progressively less. Fig. 1 shows the mean daily loss during the first stage plotted against the total loss at the end of this stage. The duration of the first stage depended on the intensity of the evaporating conditions during this period.

Such a relationship between intensity of evaporating conditions was to be expected, for in 1907 Buckingham[3] showed in laboratory experiments that the greater the intensity of evaporating conditions the sooner did evaporation-loss exceed the supply of moisture to the surface by capillarity, thus reducing subsequent loss by the formation of a surface mulch of dry soil.

As the evaporation-rate is governed by capillary supply as well as by evaporating conditions, any soil factor which reduces capillary movement may be expected to reduce the evaporation-rate. Field experiments have indicated that differences between the apparent specific gravity of a number of soil cores altered the relationship between the rate of water evaporation from the soil-surface as compared with that from a water-surface.

In other experiments it was found that the modification of the soil structure brought about by sieving influenced the rate of evaporation of water from the soil surface independently of the apparent specific gravity of the soil. This may explain differences between results obtained in these field experiments, in which the natural structure of the soil cores was undisturbed, and laboratory experiments in which sieved soil was used[2]. Further experiments at Wellesbourne have shown that even small differences in the moisture content of the surface layers affected the rate of evaporation.

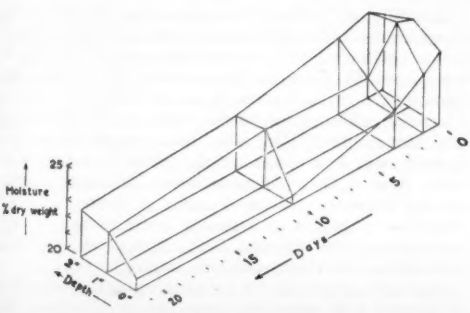


Fig. 2. Progress of drying in the top 3 in. of a seedbed

Staple and Lehane[4] have shown recently that the capillary movement of water in an unsaturated soil was affected by apparent specific gravity and moisture content, and they have described a method of estimating the rate of capillary movement from these two factors.

Detailed knowledge of the factors influencing the rate of capillary movement and a consideration of the intensity factors of evaporating conditions would enable the overall soil moisture deficit to be estimated more accurately than Penman's purely meteorological methods at present permit[5].

In addition to the overall deficit, it is desirable to know the progress of drying at various depths in order to determine the moisture environment of seeds sown in the soil. Fig. 2 shows the progress of drying in the top 3 in. of a seedbed exposed to slow evaporating conditions. After three days, the drying zone extended to 2 in. in depth, and half the deficit was in the top inch of the seedbed. After twenty-one days the deficit was demonstrable to a depth of 3 in., 55 per cent in the surface inch, 29 per cent in the second inch and 16 per cent in the third inch.

These studies of evaporation in the field are being continued, the aim being to establish the relationship between apparent specific gravity, moisture content and evaporation under the yearly cycle of evaporating conditions, and to investigate their effect on the drying of soils at various depths.

This work was done at the National Vegetable Research Station during the tenure of a Ministry of Agriculture Scholarship.

G. Stanhill

National Vegetable Research Station,
Wellesbourne,
Warwick.
March 25.

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Effect of Temperature and Initial Moisture Content on the Heat of Wetting of Wood

The results of tests by Shipley, Campbell and Maass[1] and Clarke (unpublished results), and also of tests at the Forest Products Research Laboratory (Department of Scientific and Industrial Research)[2], clearly show that the variation in the specific heat of cellulosic materials with moisture content does not follow the relation for simple mixtures. Assuming the specific heat of the cellulose to be unchanged, the apparent specific heat of the sorbed water has been calculated to be as high as 1·3 times the value for liquid water.

It can be shown thermodynamically[3] that if the heat of sorption is dependent on the temperature, T, the following relation holds:

$$c_m = \frac{1}{1+m}\left\{mc_w + c_0 + \left(\frac{\partial \Delta H}{\partial T}\right)_{p,m}\right\} \qquad (1)$$

where ΔH is the integral heat of sorption, defined as the heat absorbed when m gm. of sorbate are sorbed

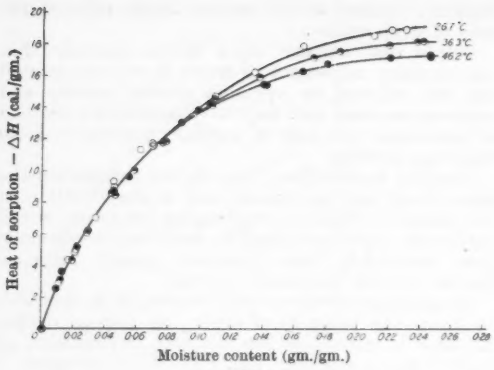

Fig. 1

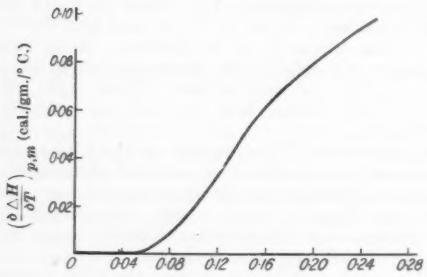

Fig. 2

by 1 gm. of pure sorbent, and c_m, c_0 and c_w are the specific heats at constant pressure of the sorbent at moisture content m, of the pure sorbent, and of the water, respectively. Wahba and Nashed[4] found that the heat evolved on wetting dry cellulose decreased with an increase in temperature, that is, at saturation $\partial\Delta H/\partial T$ was positive, and they concluded that the specific heat of the sorbed water at saturation is greater than that of liquid water.

We have determined the heats of immersional wetting of wood samples having initial moisture contents, m, ranging from 0 to 0·24 gm./gm. The tests were made at three different temperatures using an adiabatic calorimeter of the type described by Hirst and Kerridge[5]. Matched samples of ground klinki pine (*Araucaria klinkii* Lauterb.) were used, the experimental conditions being chosen so that wetting occurred as rapidly as possible. The heat of sorption, $\Delta H = \int_0^m \left(\frac{\partial \Delta H}{\partial m}\right)_{T,p} dm$, was obtained by subtracting the calorimetrically measured heat, $\int_m^{\text{sat.}} \left(\frac{\partial \Delta H}{\partial m}\right)_{T,p} dm$, from the heat of wetting of dry wood.

The variations of ΔH with both temperature and moisture content and of $(\partial\Delta H/\partial T)_{p,m}$ with moisture content are shown in Figs. 1 and 2 respectively. The results confirm the observations of Wahba and Nashed, the quantitative agreement between the two sets of data being quite good since, in both cases, the value of $(\partial\Delta H/\partial T)_{p,m}$ at saturation is 0·4–0·5 per cent of ΔH for a rise in temperature of 1° C.

Our results show that the value of $(\partial\Delta H/\partial T)_{p,m}$ decreases with decreasing moisture content. At very low moisture content its value is zero (within experimental error), and this is confirmed by the results of Taylor's isosteric measurements[6] at low relative vapour pressures, which showed that the differential heat of sorption $(\partial\Delta H/\partial m)_{T,p}$ for viscose rayon was independent of temperature at all moisture contents less than 0·02 gm./gm. Shipley, Campbell and Maass[1] found that for bleached sulphite pulp at a moisture content of 0·02 gm./gm. the apparent specific heat of the sorbed water, measured between 5° and 25° C., was 1·13, this being the maximum value observed at any moisture content. From equation (1), the corresponding value of $\partial\Delta H/\partial T$ at this moisture content is 0·0026 cal./gm./° C.; but this deviation from zero is within the experimental error of our tests.

The present results clearly show that the effect of temperature on the heat of sorption is adequate to account for the departure of the specific heat–moisture content relation for cellulosic materials from that for simple mixtures. Since the effect may be regarded as being significant compared with experimental error only at moisture contents greater than 0·12 gm./gm., it is suggested that the energy of binding of the most strongly held water is relatively unaffected by temperature.

Kathleen E. Kelsey
L. N. Clarke

Division of Forest Products,
Commonwealth Scientific and
Industrial Research Organization,
Melbourne.
March 25.

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Fitness of Microcythæmics : a Correction

I must apologize for an error I made in a communication[1] about the fitness of microcythæmic heterozygotes, published in *Nature* by Silvestroni, Bianco, Montalenti and myself. I am grateful to Dr. T. E. Reed (University of Michigan) for pointing out that, in Table 2 of that communication, there seemed to be an excess of *MM* among sibs as compared with the theoretical number if calculated from the proportion of *Mm* among the parents, given in the communication as 0·101. This query gave me the opportunity of rechecking the data and finding the error.

Actually, in Table 2 the proportion of *Mm* parents should have been given as 0·1496, and therefore the direct estimates and theoretical values for the fitnesses would have to be accordingly recalculated. However, I do not propose to do this here, because a careful examination of the data in the light of the criticism made by Dr. Reed has convinced me that, in fact, the data from which Table 2 was prepared were biased by incompleteness of ascertainment among parents and even more so among sibs (for example, only those families with tested children were taken into account, and even in these families not all the children could be tested).

Penrose's method for estimating fitness seems to be correct only when the gene frequencies have been obtained from data collected with complete ascertain-

Table 1. 1951 AND 1952 DATA: COMPLETED FAMILIES ONLY

Type of mating	No. of families	No. of children	Mean No. of children per family, and standard error	Theoretical fertility
$mm \times mm$	1,886	9,217	$4{\cdot}89 \pm 0{\cdot}138$	$2f'$
$Mm \times mm$	793	3,978	$5{\cdot}02 \pm 0{\cdot}217$	$f' + g'$
$Mm \times Mm$	79	394	$4{\cdot}99 \pm 0{\cdot}749$	$2g'$

ment. Such conditions are very difficult to satisfy in the case of human data. But perhaps the data given in Table 1 of the previous communication[1] may be used to give some further information. (This table covers data collected in 1952 as well as 1951; the heading to the table should be corrected accordingly.) The table is reproduced here in an expanded form.

The distribution of genotypes among the children is not given here, because it was determined for the 1951 sample only. Also, as stated in the previous communication, this table refers to completed families only, that is, those in which the mother was more than forty years old, and therefore presumably would not have any more children. This limitation was necessary in order to avoid having different average numbers of children per family according to the different ages of the parents. Furthermore, this table includes practically all the completed families in the districts studied. (The standard errors were calculated from the observed distributions of family size.)

In this population, M genes are constantly being lost through the death of MM individuals from Cooley's disease; so, if equilibrium is to be maintained, the Mm individuals must have some kind of selective advantage over the mm (assuming that the mutation-rate is inappreciable). Taking the frequency of the M gene to be about 0·09, corresponding to the population under consideration, Penrose's theory[2] shows that the fitness of Mm must be about 1·11 times that of mm. This assumes additive fitness (including additive fertility, as shown in the last column of Table 1); if the fitness is assumed to be multiplicative, almost identical values are obtained. This advantage may result either from a greater fertility of Mm individuals, or from a greater survival-rate between conception and reproduction, or to a combination of these factors.

An estimate of the fertilities f', g' of mm, Mm individuals, respectively, may be obtained by applying least squares to Table 1, that is, by minimizing

$$S = \frac{(2f' - 4{\cdot}89)^2}{0{\cdot}138^2} + \frac{(f'+g'-5{\cdot}02)^2}{0{\cdot}217^2} + \frac{(2g' - 4{\cdot}99)^2}{0{\cdot}749^2}$$

which gives the estimates $f' = 2{\cdot}45 \pm 0{\cdot}068$, $g' = 2{\cdot}55 \pm 0{\cdot}193$, covariance of f' and $g' = -0{\cdot}00342$. Other methods of estimation lead to substantially the same conclusions[3].

The difference between f' and g' is accordingly $-0{\cdot}10 \pm 0{\cdot}22$. Although the deviation is in the direction required for producing stability, it is insufficient in quantity and not statistically significant. Thus the data are compatible either with the assumption that there is no difference of fertility (true value of $f' - g' = 0$), or with a ratio $g'/f' = 1{\cdot}11$ (true value of $g' = 1{\cdot}11$, $f' = 2{\cdot}72$, $f' - g' = -0{\cdot}27$). On the first hypothesis, it would be necessary to suppose that the gene frequency of M is increased by a greater survival-rate between birth and reproduction, or at least that there was such a greater survival value until recently (for example, possibly acting as a protection against malaria). For data on survival, see Montalenti[3]: a difference of this kind has been established for the sickle-cell condition by Allison[4]. On the second hypothesis, the difference in fertility alone would be sufficient to maintain equilibrium. With an explanation of this kind it would have to be supposed that the fertility ratio would differ from district to district to agree with fluctuations in gene frequency. But it is clear that the evidence so far gathered is indecisive.

M. SINISCALCO

Istituto di Genetica,
Università, Naples.
April 1.

[1] Silvestroni, E., Bianco, I., Montalenti, G., and Siniscalco, M., *Nature*, **173**, 357 (1954).
[2] Penrose, L. S., *Ann. Eugen., Lond.*, **14**, 301 (1949); *Lancet*, **ii**, 425 (1950); *J. Génét. hum.*, **3**, 159 (1954).
[3] Montalenti, G., Proc. IXth Int. Cong. Genet., Supp. *Caryologia*, **6**, 554 (1954).
[4] Allison, A. C., *Ann. hum. Genet., Lond.*, **19**, 39 (1954).

"Air Pollution"

I SHOULD like to direct attention to a statement made in the leading article entitled "Air Pollution" in *Nature* of March 5 dealing with cement kilns which might be misleading.

Reference to Clauses 43–47 of the Beaver Report will show that the matter of dust emission from cement works is already subject to the Alkali, etc., Works Regulation Act, 1906, and the Alkali, etc., Works Order, 1935, which deal with scheduled processes. In 1935, cement works were specifically scheduled under this Act, which obliges the owner of any scheduled process to use the best practicable means to remove or reduce nuisance. The Act requires the processes to be operated to the satisfaction of the Chief Alkali Inspector, and various penalties are imposed for non-compliance.

It may be noted that power stations and similar coal-burning installations do not come under this Act, and the recommendation of the Committee is to bring such installations under control to a greater extent than indicated in Clause 40.

EDWARD BURKE
(Director of Research)
Associated Portland Cement Manufacturers, Ltd.,
Research Laboratories,
Stone, Greenhithe, Kent.
March 15.

IT is correct that the Beaver Report referred to the statements as set out in Mr. Burke's letter, and the Report urged an acceleration of effort in the directions desired. It is our view that the comment in the Report was not strong enough.

A parallel case arose in which reference was made in the Report to the pollution emerging from motor-car exhausts. In that case it was pointed out that legislative provision had been made; but that no effective action was taken towards abating the resulting nuisance.

We have in mind a very beautiful part of the country in which the amenities of the countryside continue to be reduced by emission from cement works. A law may exist whereby provision is made for action; but unless the law is observed it becomes ineffective. Only by sufficiently strong protest can the nuisance in question be abated.

EDITORS

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, July 11—Tuesday, July 12

Society for Analytical Chemistry (joint meeting of the Biological and Physical Methods Groups and the Scottish Section, with the Edinburgh and East of Scotland Sections of the Royal Institute of Chemistry, the Society of Chemical Industry and the Chemical Society, in the Department of Biochemistry, University New Buildings, Teviot Place, Edinburgh 8)—Meeting on "The Use of Radioactive Materials in Biological Assay".

Monday, July 11—Saturday, July 16

Society of Chemical Industry (at Birmingham)—Seventy-fourth Annual Meeting.

Wednesday, July 13—Friday, July 15

Chemical Society (at the University College of the South West of England, Prince of Wales Road, Exeter)—Symposium on "Recent Work on Naturally Occurring Nitrogen Heterocyclic Compounds".

Thursday, July 14

National Institute of Agricultural Botany (at Huntingdon Road, Cambridge), at 2.15 p.m.—Annual General Meeting.

Friday, July 15

Biochemical Society (in the Department of Agricultural Chemistry, University College of North Wales, Bangor), at 11 a.m.—Scientific Papers.

Bone and Tooth Society (at the Royal Society of Medicine, 1 Wimpole Street, London, W.1), at 3 p.m.—Discussion on some of the Proceedings of the Ciba Foundation's Symposium on "Bone Structure and Metabolism".*

Friday, July 15—Saturday, July 16

British Association for the Advancement of Science, Division for Social and International Relations of Science (in the Washington Singer Hall, University College of the South-West, Exeter)—Conference on "Land Use".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Lecturer in Inorganic and Physical Chemistry—The Registrar, Trinity College, Dublin (July 20).

Lecturer or Assistant Lecturer in Agriculture with special reference to Grassland Husbandry—The Registrar, Wye College, Wye, Ashford, Kent (July 20).

Senior Assistant in Research in the Department of Geodesy and Geophysics—The Secretary, Appointments Committee of the Faculty of Geography and Geology, Department of Geography, Cambridge (July 21).

Chemist, Senior Scientific Officer grade (with a first- or second-class honours degree or equivalent in chemistry, postgraduate research experience in physical chemistry, preferably on the properties of surfaces or of high polymers, and some knowledge of biological subjects), at the Ministry of Supply Experimental Establishment, near Salisbury, Wilts—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.458/5A (July 23).

Lecturer in Mathematics—The Secretary of University Court, The University, Glasgow (July 30).

Lecturer in Social Anthropology—The Registrar, The University, Manchester 13 (July 30).

Organic Chemist (honours graduate and preferably with experience in handling natural products, or of chromatography and enzyme work), at the Colonial Products Laboratory, London, S.W.7, for fundamental investigations into the chemistry of pyrethrum—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.465/5A (July 30).

Senior Lecturer in Agriculture—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (July 30).

Lecturer/Senior Lecturer in Biochemistry at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Sydney, July 31).

Professor of Experimental Physics, and a Lecturer in Mathematics at the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, August 10).

Senior Lecturer (with a university degree in mechanical engineering, and preferably with experience in industrial or production engineering) in Mechanical Engineering, at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 15).

Lecturer (with special qualifications in physical chemistry) in Chemistry—The Secretary, The University, Aberdeen (August 20).

Chair of Applied Mathematics at the University of Cape Town, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (August 30).

Assistant Lecturer in Anatomy, to undertake teaching and research—The Secretary, University College, Gower Street, London, W.C.1 (August 31).

Lecturer or Senior Lecturer in General and Experimental Psychology at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 31).

Lecturer (with a degree in agriculture and preferably some experience of teaching) in Agriculture, at the Imperial College of Tropical Agriculture, Trinidad—The Secretary, Imperial College of Tropical Agriculture, 40 Norfolk Street, London, W.C.2 (August 31).

Chair of Botany at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 1 Gordon Square, London, W.C.1 (September 30).

Lecturer, a Reader, and a Professor in Physics at the Chulalongkorn University, Bangkok, Thailand—Royal Thai Embassy, 21 Ashburn Place, London, S.W.7.

Lecturer (with a good honours degree, teaching and industrial experience) in Chemistry, at Rutherford College of Technology, Newcastle-upon-Tyne—The Director of Education, Northumberland Road, Newcastle-upon-Tyne 1.

Senior Physical Chemist (with a first- or second-class honours degree in physical chemistry or biochemistry, together with considerable research experience), to lead the newly formed Technological Irradiation Group, and carry out research and development work in the field of beta and gamma irradiation—The Establishment Officer, U.K. Atomic Energy Authority, Atomic Energy Research Establishment, Harwell, Didcot, Berkshire, quoting 2/103/336.

Senior Scientific Officer (with at least a second-class honours degree, and preferably with experience in electronic circuit design), for work on the design of electronic instruments and development of techniques in using such instruments in the discovery and assay of radioactive ores—The Establishment Officer, United Kingdom Atomic Energy Authority, Atomic Energy Research Establishment, Harwell, Didcot, Berkshire, quoting 2/103/273.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Institution of Gas Engineers. 92nd Annual Report and Accounts of the Council of Gas Engineers. Pp. 41. (Publication 460.) (London: Institution of Gas Engineers, 1955.) [195

Institution of Professional Civil Servants. Annual Report for the year 1954. Pp. 44. (London: Institution of Professional Civil Servants, 1955.) [195

The British Non-Ferrous Metals Research Association, 1930–1955. Pp. 48. (London: British Non-Ferrous Metals Research Association, 1955.) [195

National Institute of Agricultural Botany. Farmers' Leaflet No. 4: Lucerne. (Revised edition, March 1955.) Pp. 3. (Cambridge: National Institute of Agricultural Botany, 1955.) [205

Department of Scientific and Industrial Research and Fire Offices' Committee. Report of the Fire Research Board, with the Report of the Director of Fire Research for the year 1954. Pp. vi+48+8 plates. (London: H.M. Stationery Office, 1955.) 3s. net. [205

Department of Scientific and Industrial Research. National Physical Laboratory. Report for the year 1954. Pp. viii+98+7 plates. (London: H.M. Stationery Office, 1955.) 4s. net. [205

International Committee for Bird Preservation—British Section. Annual Report for 1954. Pp. 66+4 plates. (London: International Committee for Bird Preservation, c/o British Museum (Natural History), 1955.) 2s. 6d. [245

Building Research Station Digest. No. 76 (April, 1955): Machines for Handling Materials in Traditional House Building. Pp. 7. (London: H.M. Stationery Office, 1955.) 3d. net. [245

Other Countries

Publikationer fra det Danske Meteorologiske Institut, Charlottenlund. The State of the Ice in the Arctic Seas, 1952. (Appendix to the Nautical Meteorological Annual 1952.) Prepared by Helge Thomsen and Cmdr. M. V. L. Lorck, R.D.N.R. Pp. 22+5 maps. (Charlottenlund: Dansky Meteorologiske Institut, 1955.) [195

Research Council of Alberta. Thirty-fifth Annual Report, 1954. Pp. 47. (Report No. 69.) (Edmonton: Research Council of Alberta, 1955.) [205

Notulae Naturae of the Academy of Natural Sciences of Philadelphia. No. 256 (February 17, 1954): The pH Tolerance of the Common Bluegill (*Lepomis macrochirus* Rafinesque). By Francesco B. Trama. Pp. 13. No. 257 (February 17, 1954): The Acute Toxicity of Copper to the Common Bluegill (*Lepomis macrochirus* Rafinesque). By Francesco B. Trama. Pp. 13. No. 258 (June 3, 1954): A New Gastropod and other Fossils from the Cretaceous of New Jersey. By Horace G. Richards. Pp. 5 (1 plate). No. 259 (July 21, 1954): A New Method for Determining the Pattern of the Diatom Flora. By Ruth Patrick, Matthew H. Hohn and John H. Wallace. Pp. 12. No. 260 (September 17, 1954): Birds of Turneffe and Northern Two Cays, British Honduras. By James Bond. Pp. 10. No. 261 (November 19, 1954): Pariostegus, a Triassic Coelacanth. By Bobb Schaeffer. Pp. 6. No. 262 (November 19, 1954): The Idaho-Montana Slug Magnipelta (Arionidae). By Henry A. Pilsbury and Royal Bruce Brunson. Pp. 6. No. 263 (November 19, 1954): Mollusks from the Mississippi Delta. By Horace G. Richards. Pp. 8. No. 264 (November 29, 1954): A New Race of Gallinula Chloropus from Barbados. By James Bond. Pp. 2. No. 265 (November 29, 1954): Description of a New Blennioid Fish from Southwest Florida. By Henry W. Fowler. Pp. 3. No. 266 (November 29, 1954): Miocene Land Shell Fossils from the Dominican Republic. By Henry A. Pilsbury and Axel A. Olsson. Pp. 4. (Philadelphia: Academy of Natural Sciences of Philadelphia, 1954.) [245